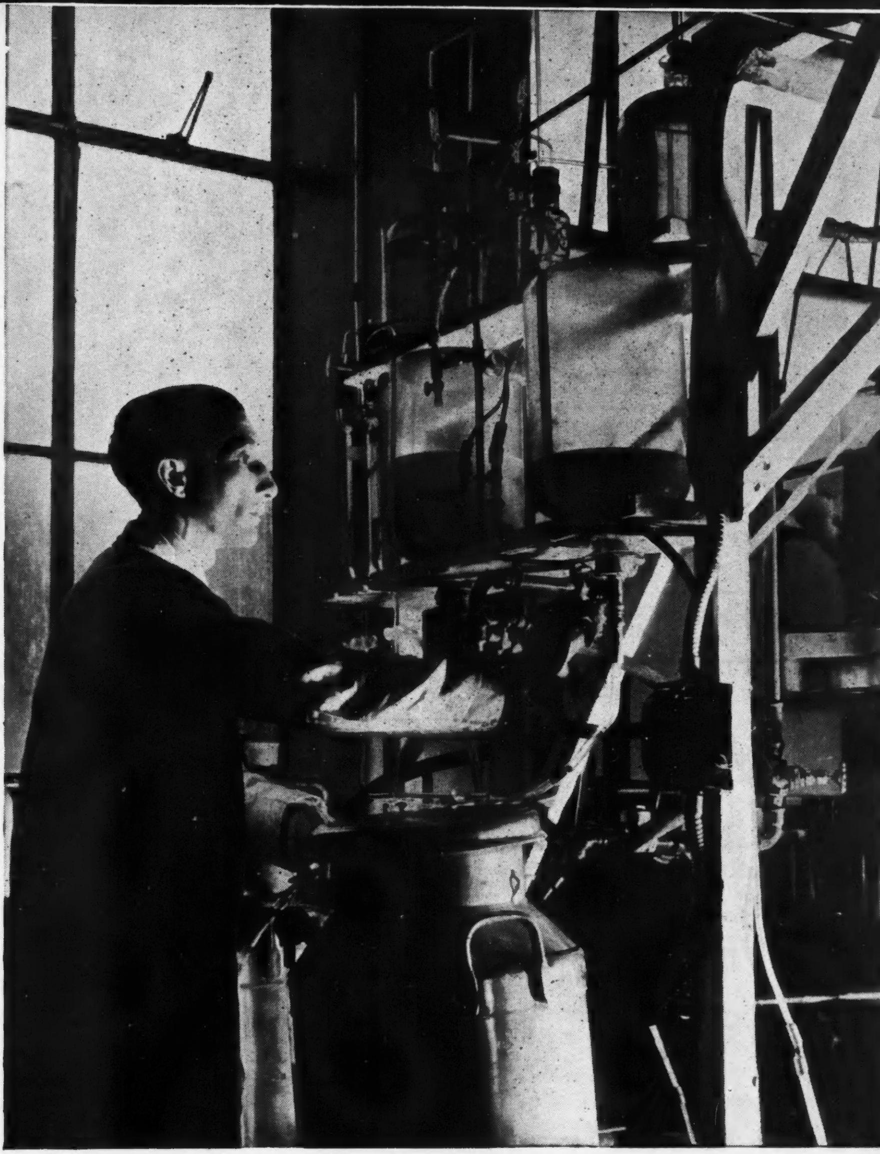
DISCOVERY



JULY
1944
1/6

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

July 1944 Vol. V No. 7 PUBLISHED AT THE EMPIRE PRESS, NORWICH, ENGLAND Tel. 21441

The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Thinking Ahead

THERE is only one piece of news—the progress of the Allied Forces overseas—and it is almost impossible to comment upon it from the scientific point of view. All that the scientists could do to help had been done long before. Their part in constructing the springboard from which the attack was launched lay in the design and invention of all the many weapons, and all the new techniques which provide the means of getting the better of the enemy. It cannot be said that the job has been done badly, for in spite of all criticism it is true that the mobilisation of scientific manpower has been carried out as well in Britain as in almost any other belligerent country. But however well the scientists did their part, in the last analysis it is on the courage and endurance of the men who use the weapons, and on the skill of those who direct the operations, that the final outcome will depend.

No one knows how long that will be in arriving, though there is now no room for doubt as to what it will be, but the stage of the war is now such that part at any rate of the thoughts of the scientist will be concerned with what is to come afterwards. That is not to under-estimate the difficulties and dangers of the final acts of the war: it is only that by the very nature of their work the scientists must always be looking ahead, anticipating the move after the next and preparing for it.

We have emphasised that although this is a scientific war, in the main, scientists do very little of the fighting. It is recognised—and the multitude of plans and reports dealing with the post-war future lend point to the fact—that the peace must be in essence a scientific peace. By that is meant that the future organisation of Britain, Europe and the world must be so framed that there is a scientific assessment of the material needs of populations, and as far as possible a scientific psychological assessment of the probable behaviour of nations under given sets of circumstances; that these estimates should then determine the post-war organisation of economics, of food, of agriculture, or raw material supply; and so on.

But here is just the point of importance. Just as the scientist is a spectator by the time the battle arrives, so he will be a spectator when peace comes. It is hardly for him to lay down political judgments, but he will have in his possession specialised information and a specialised understanding which will enable him to realise whether any particular course of action will be an attempt to transcend a definite scientific law or not. The agriculturist will know, for example, whether the proposal to raise a given quantity of food in some specified area is possible or not. The scientists will, as it were, be able to point out which factors in the situation are inelastic and which must be accepted as a framework if disaster is to be avoided.

That has to some extent been done already. The Hot Springs Conference, if it did nothing else, constituted a declaration of the realisation that a badly fed world is an unstable world in which political institutions are bound to be modified by fair means or foul in the attempt to find a remedy. We came into the war in the first place from a situation in which these elements of instability formed an essential part, and in which they manifested themselves in the phenomenon of the frustration of science. The attempt to restore a situation which flouts any such fundamental principle, or even the attempt to set up an organisation in the interests of a section of the community which aims at postponing what is for that section an evil day, is bound in the end to fail.

What then is to be done about it? The technical specialists can only act as advisors to the administrators, the politicians and all the rest. No individual can alone work out a proper policy for reconstruction, but the average citizen who takes an intelligent interest in affairs can exercise his function of criticising results and judging by them. He ought to have in mind a general picture of the sort of world he wants to live in after the war. He should say in effect: "I don't know how to get it. I employ politicians and technical experts to get these results for me. It is their job to understand these things, and I will change my staff if they don't do the job as I want it." This is in fact what the electorate should say about all political problems, but since this one is the toughest nut ever approached

by the crackers, it is all the more essential that the kernel should not be reduced to a mash in the process.

In spite of the fact that the problems of reconstruction all have a scientific background, it is not the science which is in doubt; it is the political factors which count most.

But, for the scientists themselves, what special policies should they urge? In many cases they have already urged them. The technical measures have been discussed over and over again by such bodies as the British Association and the Association of Scientific Workers (the pronouncements of the Society for Freedom in Science are still awaited) and there is general agreement on the need for food and relief, for the use of technical measures for the improvement in agriculture, and so on. In a word, the desired policy is the fullest implementation of scientific resources.

However, in a more specialised field comparatively little has been said. What is going to be done for the rehabilitation of science in Europe, for the re-establishment of research institutes and universities, for the re-starting and re-equipping of schools and colleges, for the provision of unbiased text-books, and for the removal from positions of trust of those whose coloured shirts have only just gone to the cleaners and dyers? These are points on which even the most far-sighted or cunning governments have gone astray. The Weimar republic did very little about the text-books it inherited. Franco's administration—at any rate for a time—allowed the volumes of dangerous thoughts inspired by the previous liberal administration to remain.

In this field every care must be taken to root out, not only in Germany but in other countries into which some traces of the poison may also have filtered after years of subjection, any suggestion of a division of science into "Aryan" and "Semitic": any last remnants of the influence of race theory. New books must be provided in abundance and the means of producing them in the liberated countries established without delay. The scientific apparatus which in this country may prove to have been produced in too great quantity for peace-time needs ought to be freely distributed to scientific institutions in Europe. Adequate finance for university staffs and for the interchange of personnel between this country and the liberated territories, and among themselves, must be forthcoming. In Germany itself, where a whole generation has been lost to Hitler, it may be necessary to provide the means of staffing institutions either with non-Germans of enlightened views or with specially selected refugee personnel who wish to return and who it is felt will be welcomed by a reformed administration.

These are the special measures falling within the purview of scientists and concerning which they should be able to speak with a clear mind.

On the broader questions of reconstruction the general body of scientists can play a part as private citizens, specially qualified to speak on particular technical aspects of the requirements of a stable reconstruction. What that reconstruction may be like we do not yet know. In its scientific aspects much has been promised: Parliament is generally favourable to a considerable expansion of research, at any rate in this country. On the face of it there seems some chance that the irreducible condition of a frustrated science will not be recreated, however favourable that might be to sectional interests. But that is only the face of the matter. So far the only concrete gain is the allocation of considerable funds to the British Coal Utilisation Research Association. The Parliamentary and Scientific Committee's plans still have to weather the storms of the House. The situation is not one in which a change of Government hostile to these new proposals would be unable to reverse them.

Chemistry Comes of Age

As the eighteenth century gave way to the nineteenth chemistry was becoming an exact science. Precise measurements of masses, volumes and temperatures were possible. Results were being expressed in terms of numbers, and the existence of regular relationships between these numerical results was becoming clear. The essential foundations of exact knowledge were being laid, on which was later to be built the edifice of modern physics and chemistry with its account of the properties of gross matter in terms of its ultimate atomic and electronic structure.

The atomic idea was as old as the Greeks, who had got it from the purely philosophic hypothesis that it must be impossible to continue indefinitely the division of a lump of matter into smaller and smaller pieces. This was not a scientific idea because the conclusion that this must be the constitution of matter was accepted without experimental test, nor did it ever form the basis of further deductions of a practical character. The vague notion remained and is seen as an influence on the writings of many later scientists, but it did not acquire the status of a scientific hypothesis until it was given a clear and unambiguous formulation by John Dalton, who died a century ago on July 27th.

In the simple, lucid and beautiful English style, similar to that of so many other great scientists, Dalton said: "Every particle of water is like every other particle of water; every particle of hydrogen is like every other particle of hydrogen, etc. When any body exists in the elastic state its ultimate particles are separated from each other to a much greater distance than in any other state; each particle occupies the centre of a comparatively large sphere, and supports its dignity by keeping all the rest, which by their gravity or otherwise are disposed to encroach upon it, at a respectful distance. Chemical analysis and synthesis go no farther than to the separation of particles one from another and to their reunion. No new creation or destruction of matter is within the reach of chemical agency."

These were the ideas which first appeared in his note-books in 1802 and which he published in his *New System of Chemical Philosophy* in 1808, although they had been included in his lectures before that time. He himself had been led to them through his own experiments, rather rough and inaccurate though they were even by contemporary standards, on the combining proportions of elements and on the partial pressures of vapours. The route of his own thought starting with his meteorological observations first published in 1793, through the study of vapours to the processes of chemical change, is one which is easy enough to follow. But independent though he was, his track was being paralleled by other workers in other countries. The appreciation of the need for precision and the possibility of attaining it was world wide, and Dalton must be seen as one of a group of workers, who,

perhaps influenced by contemporary economic developments, were introducing quantitative measurements and ideas. In France, Proust had enunciated the law of Definite Proportions for the combination of chemical elements, and Guy-Lussac had derived the laws of the combination of gases. Berzelius in Sweden was carrying out chemical experiments of great accuracy, and in 1811 Avogadro was to formulate his hypothesis that equal volumes of all gases under the same conditions of temperature and pressure contain equal numbers of molecules.

The times were such as to encourage the growth of these new ideas. It was the time of the Napoleonic Wars and of the introduction of machinery into industry, and it can hardly be supposed that Dalton and his fellow members of the Manchester Philosophical Society were indifferent to the kind of changes which must have been taking place in their own immediate surroundings.

Dalton was born in 1766 in Cumberland, the son of a handloom weaver. Only three—Jonathan, Mary and John—of the six children survived infancy. John's early education proceeded under the kindly direction of a well-to-do relative, and he began teaching in the village school at the age of 12. At 15 he moved to Kendal and continued teaching, becoming principal of a school, which he ran with his brother, when he was 18. In 1793, at the age of 26, he went to Manchester as tutor in mathematics and natural philosophy at the New College, a nonconformist foundation out of which eventually grew the present Manchester College at Oxford.

While he was at Kendal, Dalton began contributing scientific to the *Gentlemen's Diary* and the *Ladies' Diary*, and started his meteorological diary. At this time, too, he began giving series of public lectures, which were however none too successful.

In 1799, in order to give himself more opportunity for research, he gave up his tutorship and began to maintain himself by private tuition. Recognition of the atomic theory came rather slowly, but by 1803 Dalton was well-established and was giving a series of lectures at the Royal Institution in London, which was followed by a second series in the winter of 1809 to 1810. These were two of his rare absences from Manchester, except for his annual holiday in the Lake District. For 25 years he shared a bachelor establishment with a friend, the Rev. W. Johns, leading a quiet retired life fitting to his Quaker persuasion. His dress was the sober habit appropriate to the Society of Friends, and this led on two occasions in his life to rather odd little incidents.

In 1832 he was given the degree of Hon.D.C.L. by the University of Oxford, and it was expected that Dalton might raise difficulties over the wearing of the gay scarlet robes appropriate to that honour. However, Dalton and his brother Jonathan had discovered at the age of 26 that they were both colour blind (an interesting fact from the genetical point of view) being unable to distinguish red from green. To Dalton his robes seemed "dirt-coloured" and he made no objection to wearing them. The same solution was found later when he was presented to George IV. Court dress with its sword was impossible, and the dirt-coloured robes provided a way out.

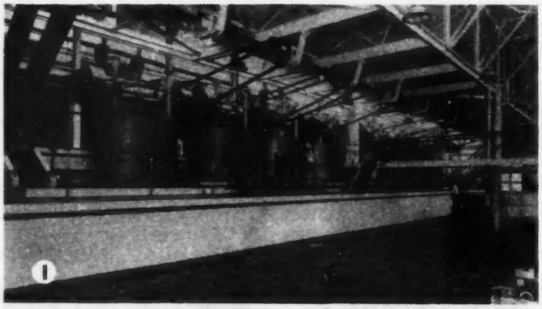
Apart from these ventures into high life, Dalton's later career drew quietly on with increasing honour. The tardy election as a Fellow of the Royal Society came in

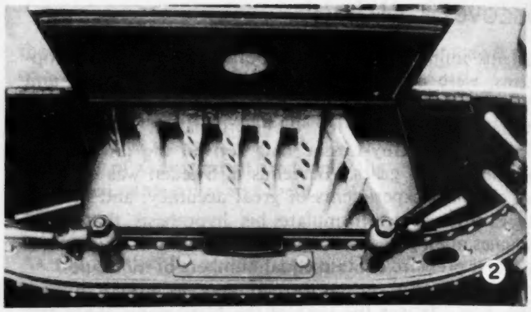
1822; the first Royal Medal of the Royal Society in 1826; and a civil list pension, subsequently increased, in 1833. In the next year he sat to Chantrey the sculptor for his statue, which bears a strong resemblance to that of Sir Isaac Newton, and which is still to be seen in Manchester.

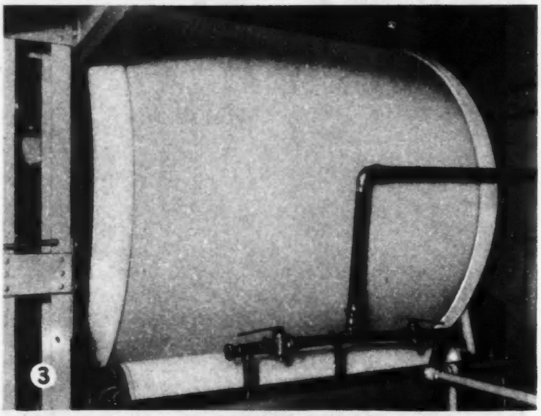
When he was presented at Court by the able but snobbish mathematician, Charles Babbage, bystanders, seeing his scarlet robes, asked if he were a provincial mayor come to receive some minor honour. The reply was that the name of Dalton would be remembered when those of provincial big-wigs were long since forgotten. After 100 years his memory is as fresh as ever, and the long chain of precise investigation which he played so large a part in starting is still being lengthened by his successors.

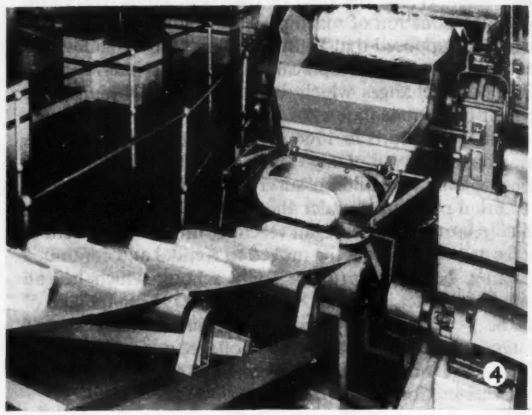
Margarine

APART from its importance, especially in war-time, as an item of daily diet, margarine is of considerable interest on account of the surprisingly large number of chemical and physical principles involved in its manufacture. Margarine was first made in Paris in 1870 by a process devised by the French chemist Mège-Mouriès. In an attempt to relieve the serious shortage of fats resulting from the German invasion of France, the French government offered a substantial prize for the invention of a satisfactory method of preparing a substitute for butter. By Mège-Mouriès' method









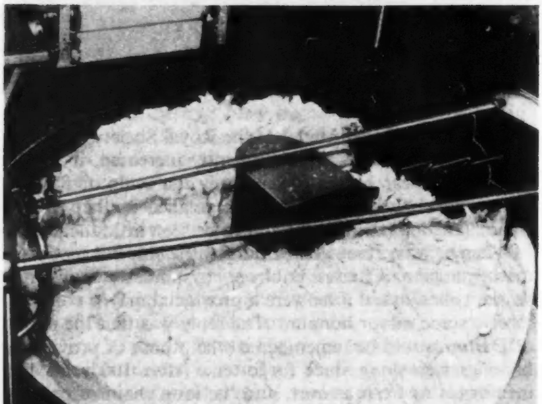


FIG. 1.—Shows the churns in which the ingredients of margarine are mixed. FIG. 2.—Is the top view of one of the churns shown in the previous picture. FIG. 3.—Depicts one of the huge cooling drums over which the oil and milk emulsion is frozen. It is then automatically scraped off the drum into trucks below. FIG 4.—Indicates the multiplex process which gives the margarine a consistent texture before it is carried to the kneading tables shown in the next picture. FIG. 5.—Margarine on the kneading table shown in this picture is beaten with paddles to perfect its texture. FIG. 6.—M. Mège-Mouriès, "the father of margarine," devised the first process for making margarine at the time of the Franco-Prussian war of 1870. (*These pictures are reproduced by the courtesy of Messrs. Van den Berghs and Jurgens, Ltd.*)

beef suet
and finely
the latter
would sep
was remo
into two
fats, or ol
water unt
was added
and stand
excellent b
given the
To-day m
tons week
originally
variety of
devised to
Modern
15% to 30
used and
run into la
special str
those whi
this "ripe
obtain a b
strains of
usually is
investigati
of butter
acetyl m
synthetica
When the
with the
warming,
formed.
oil emuls
pended i
churning
the marg
water on
adding o
microscop
tiny the m
it keeps
warm emu
with ice-
as a good
uniform
colouring
or an a
preservat
is allowe
until it is
kneading
has been
formed a
was despa
generally
domestic
found to
ties. Ma
then rema
A very

beef suet was digested, at 113°F., with a little soda and finely shredded sheep's stomach. The purpose of the latter was to provide a substance, pepsin, which would separate the fat from the cellular tissue. The fat was removed and, by application of pressure, separated into two fractions. The first fraction, consisting of soft fats, or oleomargarine, was then churned up with milk and water until a thick cream was obtained, to which anatto was added to give it a butter-like colour. After cooling and standing, a product was obtained which proved an excellent butter substitute and from its pearly lustre it was given the name of margarine (Latin *margarita*, a pearl). To-day margarine is produced at the rate of thousands of tons weekly, but the process used is still similar to that originally employed. The main difference lies in the variety of different fats now used and in special techniques devised to increase the resemblance to butter.

Modern margarine consists of fat incorporated with 15% to 30% of its weight of milk. Skim milk is generally used and this is sterilised by pasteurisation. It is then run into large vats, warmed to 70°F., and inoculated with special strains of lactic acid producing bacteria, similar to those which normally turn milk sour. The purpose of this "ripening" process, which takes 12 to 15 hours, is to obtain a butter-like aroma and flavour. To this end the strains of bacteria used are carefully selected, and are usually isolated from highly aromatic butter. Chemical investigation has shown that part of the aroma and flavour of butter is due to two simple substances, diacetyl and acetyl methyl carbinol. These substances, prepared synthetically, are therefore often added to margarine. When the ripening process is complete the milk is mixed with the requisite amount of fat, previously softened by warming, and churned vigorously until a thick cream is formed. This cream is known technically as a water-in-oil emulsion, and consists of tiny drops of water suspended in the oily material. Careful control of the churning is essential. If an oil-in-water emulsion develops the margarine soon turns rancid and exudes drops of water on storing. The right type of emulsion is secured by adding oily stabilisers. The watery drops, although of microscopic size, must lie within a definite range. If too tiny the margarine has a cloying, fatty taste: if too large it keeps badly and loses weight by evaporation. The warm emulsion is cooled by passing between rollers cooled with ice-water. Here too careful control is necessary as a good product is obtained only when the cooling is uniform and rapid. Before cooling either a natural colouring substance such as caratin or anatto is added or an approved food dye. In peace-time no other preservative is permitted by law. The cooled emulsion is allowed to stand and is then kneaded mechanically until it is of the right consistency for use. Generally kneading is done in a chamber from which all air has been pumped out: otherwise air-bubbles are formed and the product is frothy. Formerly magarine was despatched from the factories in bulk, but to-day it is generally sent out in ½ lb. or 1 lb. packages ready for domestic use. Even the type of wrapping paper used is found to exert a considerable effect on the keeping qualities. Margarine is best stored at about 40°F. and should then remain good for 6 to 8 weeks.

A very great variety of fats and oils are now used in margarine factories, and by suitable blending different types of margarine can be prepared for different purposes. For ordinary use the fats used should melt between 50°F. and 90°F., but for summer and tropical use, or for use in hot bakehouses, the limits may be 75°F. to 90°F. It is, however, essential that the fat should melt completely below the temperature of the body; otherwise it leaves an unpleasant greasy taste in the mouth. Of the many fats and oils now in use some of the commonest are lard, beef tallow, whale, olive, coconut, ground nut, cottonseed, palm and sesame oils. For blending purposes many of the liquid oils, which give a "runny" emulsion, can be brought to a firmer consistency by causing them to take up hydrogen. This is done by passing the heated oils mixed with hydrogen gas, over nickel catalysts. Under these conditions chemical combination takes place and the hardness of the product can be controlled by regulating the temperature and the amount of hydrogen gas. The oils most frequently treated in this way are whale, ground nut and cottonseed.

A recent development is the replacement of the milk commonly used by artificial milk prepared by grinding up almonds or soya beans with water until a thin emulsion is obtained. As a result it is now possible to prepare margarine entirely from vegetable sources.

From the dietetic point of view the main constituent of margarine is its fat. Fat is used by the body as a source of energy, and in this respect margarine is, weight for weight, of very much the same value as real butter. In addition to its fat content, however, butter is a valuable source of vitamins A and D. Before the war some manufacturers were already overcoming the lack of vitamins in margarine by incorporating the two vitamins in their product. Since the war commenced the so-called "National" margarine has all been treated in this way. The vitamin A is generally obtained as a concentrate of certain fish-liver oils. The vitamin D is a semi-synthetic product prepared by the irradiation of sterols derived from natural resources. As a result the margarine manufacturer is able to offer a product in which, unlike butter, the vitamin A and D content is the same all the year round. Margarine is also much more free than butter from bacterial contamination. This is a result of the extreme cleanliness of manufacture, a condition required both by law and expedience. A very tiny amount of rancid material, left in the plant from a previous operation, can ruin the flavour and keeping qualities of tons of margarine.

Investigating Explosions

THE subject of explosions has more than a military interest. Not only are explosives extensively used in mining and quarrying, but the actual processes which happen in an explosion are of very great interest because they throw light on the behaviour of gases under exceptional circumstances and on the way in which a rapid chemical reaction moves through the gases involved. It is easy enough to determine the physical and chemical conditions before the explosion has taken place, and again after the whole process is over. Both change only slowly with time and do not require any very specialised technique for their measurement. Where the real interest lies is in the momentary values of, for instance, the temperature and

pressure in the gases, either at a single point through which the explosive flame is passing, or at some point moving with the flame front. To measure these conditions is as difficult as it is interesting. Take for example the measurement of temperature. Physicists have possibly half a dozen different methods readily available by which even very rapidly varying temperatures can be measured. For instance, the electrical resistance of a wire of platinum varies with temperature and so provides one kind of high-temperature thermometer. Again, if two wires of different metals are joined so as to form a loop and one junction is made hotter than the other, an electric current will flow in the loop which can be used to determine the temperature difference between the two joins.

However, as the chemical engineer well knows, the conditions of chemical reaction in gases can be greatly affected by the nature of a metallic surface in contact with the gas. Thus if we sought to measure the temperature of a gas in the act of explosion by putting in a platinum resistance thermometer or one junction of a thermo-couple (the technical name for a loop made of wires of two different metals) we might easily produce a small region round the measuring device in which the chemical reaction went on at quite a different rate and in a different way from that in the main body of the gas. We should in fact measure not the conditions we were seeking to investigate, but different ones produced by our measuring instrument itself. This of course happens in all measurements, but in many of them the alteration in conditions produced by the measuring instrument itself is so small as to be negligible.

One way of getting over this difficulty is to put the mixture to be exploded into a soap bubble, and then with some form of high speed recorder to register its expansion from which the temperature and pressure produced can be inferred. However, in a recent paper Dr. A. Smeeton Leah describes a method which permits the investigation of the progress of temperature and pressure in considerable detail throughout an explosion lasting less than one-tenth of a second.

He exploded mixtures of oxygen with a large excess of carbon monoxide in a closed steel vessel of 17·45 inches diameter. During the explosion two sorts of observations were made. One was a visual record of the actual progress of the explosion flame outwards from the initial spark at the centre of the sphere, and the other was a measurement of pressure.

The visual observations were made through a hole in the side of the sphere in which lenses were fitted so as to produce an image on a recording drum. The explosion produced a globe of inflamed gas which grew in size from the centre of the container. The image of this fell on a slit before reaching the recording drum, so that in fact what was observed was the progress of the explosion along a diameter of the sphere. Thus during an explosion an illuminated streak of increasing length was produced on the recording drum. The turning of the drum during the process placed successive streaks side by side, so that the complete record was produced as a wedge. The point of the wedge represented the instant of ignition and the widening of the wedge represented the successive stages of the progress of the explosion.

The pressure in the steel container was recorded by means of a diaphragm placed in another hole in the wall. With increased pressure this diaphragm became bent, its movement being registered by means of two small mirrors mounted on its outer face. As the diaphragm became more or less bent these mirrors were tilted to a greater or less degree and a thin pencil of light falling on them was deviated to a greater or less extent. This pencil of light was also allowed to fall on the recording drum producing a trace as the drum turned whose movement registered the pressure in the container.

Dr. Smeeton Leah found that he could obtain rather satisfactory observations of explosions of mixtures containing 13% of oxygen and 87% of carbon monoxide with some variation in these proportions. The importance of the proportions is that they determine the rate of explosion, which must not be too slow because then the gases have time to move and mix during the explosion, nor too fast, because then the inevitable lag in the pressure recording device makes the correlation of the pressure record with the visual one uncertain.

With the proportions mentioned it was found that the burning globe had reached a diameter of 6 inches at 0·0435 seconds after the spark was passed, and a diameter of ten inches at 0·0755 seconds. In this time the pressure increased by about 25%. This of course means the pressure at the surface of the container, and by assuming that this outer shell of gas was being compressed by the expanding explosion globe, Dr. Smeeton Leah was able to calculate what the temperaure must be. Thus he found it to be 1520°C. when the explosion globe was 6 inches in diameter and 2310°C. when it was 10 inches in diameter.

The technique so far developed is suitable apparently for rather slow and not very violent explosions—it is easy to see that the flame front moves outwards at about only ten feet per second—but it is a technique which is extremely neat and likely to be of great importance when developed for further studies.

REFERENCE:
Investigating Explosions: *Philosophical Magazine*, 34, December 1943, p. 795.

Professor Dame Helen Gwynne-Vaughan, G.B.E., D.Sc.

WILLIAM E. DICK

WHEN Dame Helen Gwynne-Vaughan retires in September after 35 years as head of the botany department of Birkbeck College she will be leaving behind her a distinguished record of achievement. Not only has she accomplished a considerable amount of original research, written one standard textbook, and enjoyed the distinction of being one of the first women to hold a university professorship at a co-educational college, but also, to mention only one out of a great number of "extramural" activities, she is to be credited with having played an important part in organising the women's service auxiliary to the British Army in both this war and the last. (In view of the aspersions so often cast on the administrative worth of scientists the latter work deserves particular emphasis.)

Helen Charlotte Isabella Gwynne-Vaughan was born in London in January, 1879. She was the elder daughter of Capt. Hon. A. H. D. Fraser, who died while she was yet a child. A great-uncle on her mother's side was Dr. Hugh Blackburn, mathematics professor at Glasgow University. For the most part she was privately educated, except for the year which she spent at Cheltenham Ladies' College. By the time she came to leave that school she had already made up her mind that she wanted to study biology. This wish did not derive from a school introduction to the subject; no biology was taught there and indeed the only science she learnt during her schooldays was a little chemistry. The chance to extend her scientific knowledge did not come until four years after she had left Cheltenham Ladies' College. The idea that she wished to make a career, and moreover a career *in science*, must have struck her mother and her stepfather as somewhat strange, for at that time very few girls gave a thought to earning their own living unless circumstances compelled them to do so. But after satisfying themselves of her keen and serious intention to study, her parents agreed to her entering a London college. So she embarked upon her career, with an annual allowance of about £100 to pay for her lodgings and her fees and to meet all other expenses. She matriculated at King's College, where she took her Inter B.Sc. in chemistry, mathematics, botany and zoology and was the first woman to become a Carter Medallist. Her original aim was to continue to an honours degree in zoology, but since there was no course for that purpose at King's she turned to botany. The phrase "reading for a degree" was never more literally true than in her instance, for there were no regular lectures she could attend—in fact that first course of honours botany lectures she ever heard were the ones she herself gave after graduation.

While still an undergraduate she took a post as a temporary assistant at the Natural History Museum, where she worked in the mycological department under the direction of V. H. Blackman, then the museum's expert on fungi. It was a curious appointment by modern standards, for her pay as an assistant was determined by piece rate—so much for each specimen identified, so much for each label—but it did provide her with valuable experience in systematics. It also gave her the opportunity to start research, which she did in collaboration with V. H. Blackman, the outcome of that research being three papers on the sexuality of various fungi. In those days members of the museum staff used to take on a certain amount of teaching in London University (the practice still continues, I believe), and Miss Fraser acted as demonstrator at the set of intercollegiate lectures which V. H. Blackman gave at University College.

In 1904 she graduated, and three years later she obtained her doctorate. The first full-time teaching post she held was at Royal Holloway College, where she demonstrated in the botany department directed by Dr. (later Professor) Margaret Benson. During the enforced absence of Dr. Benson for the greater part of one session she became a lecturer and was given the responsibility of supervising several honours students as well as other pupils. With one of those students, Miss H. S. Chambers, she was later to collaborate in research.

She obtained a lecturership at University College, Nottingham, in 1908, returning to London in September 1909 to fill the vacancy in the botany department of Birkbeck College which arose when Professor D. T. Gwynne-Vaughan left to go to Belfast. In 1911 she married her predecessor. Whereupon she applied for a post at Belfast, only to be told that the authorities could not contemplate having a professor's wife as a member of the faculty. Her husband, a great botanist known throughout the world for his work on ferns and in palæobotany, died in 1915 at the early age of 44.

In Khaki

When the Great War began Mrs. Gwynne-Vaughan joined the V.A.D's, and afterwards took a special war-time course of medical bacteriology at King's since that line of war service seemed most appropriate for her civilian experience. "I think I had visions of a mobile laboratory on some really dangerous front," she has since remarked. Those hopes, however, did not materialise, but though no war-time use was found for her scientific talents her ability as an administrator was not wasted. Towards the end of 1916 the shortage of manpower on the Western Front had become acute, and the Commander-in-Chief in France was asked by the War Office whether he would accept women as replacements for fit men along the lines of communication. He agreed, and in February 1917 the Army Council, recognising that such a force must be uniformed and disciplined, founded the Women's Army Auxiliary Corps and appointed Mrs. Gwynne-Vaughan as its senior officer in France, with the rank of chief controller (which was, at first, roughly equivalent to that of a lieutenant-colonel). The setting up of the W.A.A.C., later known as Queen Mary's Army Auxiliary Corps, revealed naturally enough a good deal of prejudice against the entry of women into a military organisation, a prejudice soon overcome by the excellent work and discipline of the women. One anecdote in this connection is relevant. Mrs. Gwynne-Vaughan, to make conversation during a long journey, asked the officer who shared her car whether his wife was interested in the W.A.A.C. and back came the reply "My wife, Mrs. Gwynne-Vaughan, is a truly feminine woman." Recording the incident in her book *Service with the Army* Dame Helen comments: "It has stuck in my mind because it voiced exactly a common point of view that there was something rather bold and *not quite nice* about the auxiliary services. We never had the reclamé so readily accorded to hospital personnel, yet cooking for hungry men is also a 'womanly' activity". (That officer's attitude was not unknown at the start of this war, when many a slander born in the Great War was revived and repeated against the women's services, but this time the phase of extreme prejudice passed more quickly, the change in the public's attitude being accelerated no doubt by the exigencies of total war.)

Dame Helen's task in France was not an easy one, and the well-organised, well-disciplined corps which emerged before the war ended and which was the pattern for the present A.T.S., bore witness to the chief controller's powers of administration and to her perseverance. In September 1918 she was lent to the Air Council and then transferred as commandant to the Women's Royal Air Force, forerunner of the W.A.A.F. Her services to the W.A.A.C. were recognised by the award of the C.B.E. in 1918, and later, on the recommendation of the Air Council, she was given the D.B.E., both being military honours.

Research School at Birkbeck

One of the first things she did after her return to Birkbeck in December 1919 was to complete the book on fungi she had started writing before the war. Out of that volume (*Fungi*, 1922) there was later developed a textbook familiar to most botany students, *The Structure and Development of the Fungi*, which she wrote in collaboration with her assistant, Dr. B. Barnes. 1920 saw Birkbeck become a college of London University, and Dame Helen then gained the status of professor.

The fact that Birkbeck College is an educational centre for evening centres allows the staff a great deal of time for research work or extramural activities, and in the years after the war we find Dame Helen dividing her free hours between scientific investigation and a wide range of activities outside the college. On three occasions she stood as Conservative candidate for North Camberwell. Though she was unsuccessful she found the experience interesting—"I learnt thereby still more about human nature. I gained, too, from street oratory in the Old Kent Road an increased facility of speech as well as many friends", was her own view of the venture—and it led to her being invited to serve on a number of Government, including the Royal Commission which reviewed food prices in 1924.

One of the first botanical honours she received after the war was the Trail Medal of the Linnean Society. In 1925 she was elected to the Senate of London University, on which she served for five years. At the meeting of the British Association in Glasgow in 1928 she was president of the botanical section, and in the same year she was president of the British Mycological Society. The following year brought the award of the G.B.E.

She had, of course, soon taken up again the threads of her research work. Before 1914 she had studied the cytology and life histories of various fungi. One of her collaborators had been Miss H. S. Chambers, and in the 1920's they renewed their co-operation. (In the meantime Miss Chambers had been married, so that the partnership which opened under the names of "Fraser and Chambers" was resumed with the false appearance of being under new management; the references in the literature now reading "Gwynne-Vaughan and Williamson"). Dame Helen's researches have been mainly concerned with the nutrition and the phenomenon of sex in fungi. The conception of brachymeiosis (whereby a double reduction division occurs in the development of ascospores, and a nucleus, at first tetraploid, becomes haploid) was entirely hers. She has

[*Continued on p. 219*

Penicillin

T. I. WILLIAMS, B.A., B.Sc.

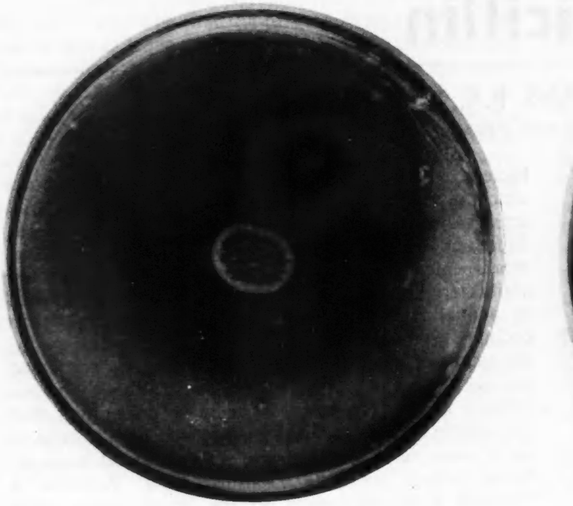
of the Sir William Dunn School of Pathology, Oxford

BACTERIOLOGISTS have for a great many years been familiar with the fact that certain species of bacteria and fungi can interfere with the growth of others. As long ago as 1877 Pasteur, the celebrated French chemist who first demonstrated the bacterial origin of disease, showed that contaminating organisms would inhibit the growth of the anthrax bacillus. In 1889 another Frenchman, Bouchard, showed that liquids in which an organism now known as *Pseudomonas pyocyanea* had been growing, had the property of destroying certain types of bacteria which are harmful to man. Ten years later other workers attempted to use concentrated and purified preparations of the liquid for the treatment of diphtheria and other infections. They claimed that in animals their preparation could cure experimentally induced anthrax. They named their product pyocyanase, and although its therapeutic value is questionable it has been on sale in Germany until quite recently. In 1924 it was shown that a micro-organism known as actinomyces produced a substance, named actinomycetin, which destroyed many pathogenic (disease-producing) bacteria. In the same year the production of antibacterial substances by organisms present in the soil was described.

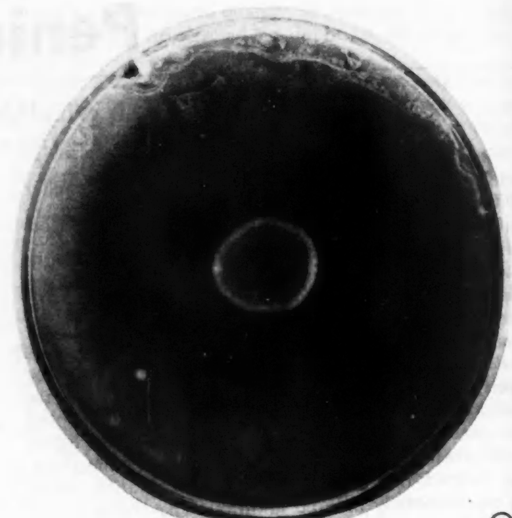
Discovery of Penicillin

In recent years the name antibiotic has been used to describe such antibacterial products of micro-organisms. By far the most important antibiotic yet known is penicillin, discovered in 1929 by Professor Alexander Fleming of St. Mary's Hospital, London. Its discovery was due to a combination of good fortune and acute observation. Fleming noticed that a culture of staphylococci (bacteria which are a common cause of septic infection) had been contaminated by a green mould which had dropped on to the plate from the air of the laboratory. He observed that around the small colonies of the mould the staphylococci were disappearing. His good fortune in having the opportunity to make this observation was shown in more ways than one. The bacteriologist is concerned to avoid contamination of his pure bacterial cultures and takes elaborate precautions to prevent this occurring. Consequently contamination of cultures rarely occurs and when it does they are generally rejected as useless. In this particular case, however, the peculiar effect of the contaminating mould attracted the attention of Fleming's trained eye. He was interested in the antagonism between the mould and the bacteria, and isolated pure cultures of the former to investigate its properties in greater detail. On examination the mould proved to be a species known as *Penicillium notatum*, and from the descendants of these original colonies all the world's supply of penicillin has been obtained until quite recently. He found that the mould would grow readily on liquids, such as the broth on which many bacteria are cultivated, and that during growth it secreted into the liquid a substance which had a considerable activity against many types of pathogenic bacteria, particularly the staphylococci and streptococci which give rise to septic infections. The antibacterial activity was still detectable even when the broth was diluted as much as 800 times. Fleming named the active broth penicillin—to-day this name is applied to the pure antibacterial substance contained in the broth. He showed by animal experiments that it was not more toxic than ordinary broth and appreciated the possibility of its use for the local treatment of septic wounds. He also originated the use of penicillin as an aid to the isolation of various bacteria in the laboratory. It must be understood that remarkable as the properties of penicillin have proved to be, it does not by any means act against all bacteria. Some bacteria are quite insensitive to it. Penicillin is therefore extremely useful to the bacteriologist as a means of separating those bacteria which are sensitive to it from those which are not.

Following Fleming's observations an attempt was made to isolate the active substance from the broth, or at any rate to produce more concentrated forms of it. However, it soon became apparent that penicillin was an unstable substance which readily lost its antibacterial properties. As there was at that time no appreciation of the remarkable nature of these antibacterial properties, which have been discovered only during the last few years, chemical investigation was not pursued. To the layman it may seem strange that so remarkable a substance could so easily mask its properties. Several factors contributed to the failure to recognise the unique properties of penicillin at that time. Although salvarsan (Ehrlich's 606) was being successfully used for the treatment of syphilis, a long search for other substances which would attack bacteria without harming the patient had proved unsuccessful. A great number of antiseptics had been investigated. While many proved satisfactory for the control of purely local infections, for sterilising surgical instruments and similar purposes even to-day exceedingly few substances are known which can be used for the treatment of infections involving the body as a whole. For this purpose the drug must be introduced or absorbed into the blood stream and under these conditions almost all substances which act against bacteria also act against the tissues of the body and cause severe toxic symptoms in the patient. Penicillin owes its unique properties to its power of acting specifically against bacteria instead of against living cells in general. The day of the sulphonamides (drugs of the M & B type), now so widely used, had not then dawned and current scientific opinion was sceptical of the possibilities of bacterial chemotherapy. Fleming's work was not sufficient to demonstrate the phenomenally high activity and low toxicity of penicillin because at that time there was no means of telling how much pure penicillin the active broth contained. Without this knowledge no absolute estimate of its powers was possible. We now know that the broth contains less than one part of pure penicillin in one hundred thousand parts of liquid.

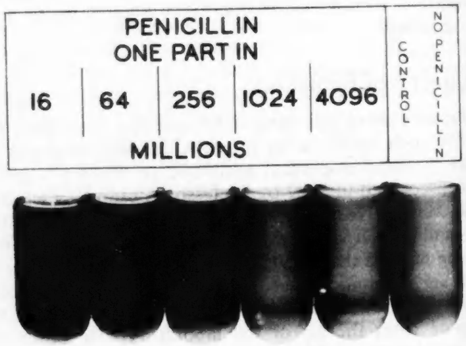


(1)

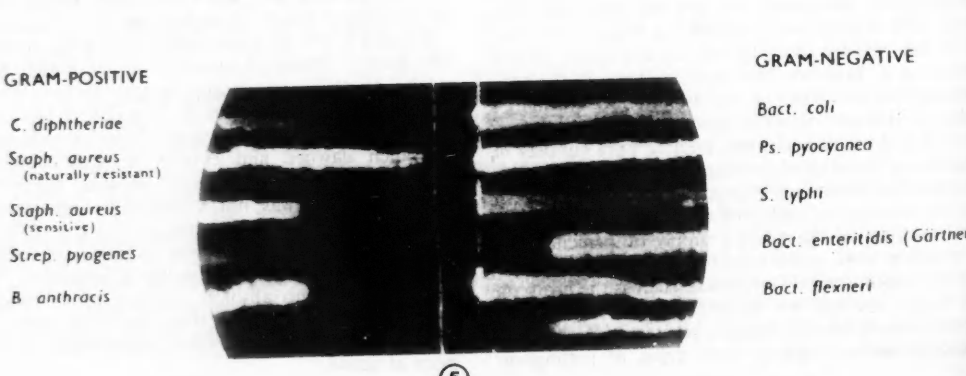


(2)

(3)



(4)



(5)

Detailed

The inv
not there
chemothe
Had this
pressed o
however,
years. In
of the Si
undertoo
atic inve
involved
reading t
the descri
attracted
determine
of liquids
time they
and to cla
science: c
results to

Perhaps
similar fie
the diffic
pioneer w
Pathology
departme
research
stages be
specialist
A. D. Ga
teriologic
on the bi
tions we
by Dr. E
have bee
Robert R
Perrins L
A. G. Sa
the extra
method c
clinical i
were unc
Dr. M. E
investiga
became c
penicillin
of war c
with all p
Florey a

FIG. 1.–
agar plate
Into this p

FIG. 2.–
visible effe
substance

FIG. 3.–
into the ag

FIG. 4.–
penicillin i

FIG. 5.–
diffuse out
agar in st
ones have

Detailed Investigation

The investigation set in train by Fleming's discovery did not therefore demonstrate that in penicillin we had a chemotherapeutic agent of quite an exceptional nature. Had this been realised research would of course have been pressed on with all possible speed at the time. As it was, however, all interest in penicillin died down for nearly ten years. In 1938, Professor H. W. Florey and Dr. E. Chain of the Sir William Dunn School of Pathology, Oxford, undertook, for purely academic scientific reasons, a systematic investigation of the chemical and biological factors involved in the antagonisms of micro-organisms. In reading the already considerable literature on the subject the descriptions of penicillin given by Fleming and others attracted their attention and it was decided to make a determined effort to isolate penicillin, the active principle of liquids on which the mould had been grown. At that time they did not anticipate doing more than to add to, and to clarify, knowledge of a relatively obscure branch of science: certainly they could not foresee the sensational results to which their work was to lead.

Perhaps only those who have actually worked in this or similar fields can fully appreciate the nature and extent of the difficulties involved in such an undertaking. The pioneer work was done at the Sir William Dunn School of Pathology, Oxford, with the collaboration later of other departments of the University. A team of distinguished research workers was assembled and the work has at all stages been characterised by close collaboration between specialists in many different fields of science. Professor A. D. Gardner has collaborated throughout on the bacteriological aspects of the work and Dr. M. A. Jennings on the biological investigations. The chemical investigations were initiated at the Dunn School of Pathology by Dr. E. Chain and Dr. E. P. Abraham, and since 1942 have been continued in collaboration with Professor Sir Robert Robinson and Dr. Wilson Baker of the Dyson Perrins Laboratory, Oxford. Dr. N. G. Heatley and Dr. A. G. Sanders devised and built the laboratory plants for the extraction of penicillin and the former developed the method of assay now in general use. When the stage of clinical investigation was reached the first observations were undertaken by Dr. C. M. Fletcher and, later, by Dr. M. E. Florey. By the time the exhaustive preliminary investigations were completed the war had started and it became clear that apart from its obvious humanitarian value penicillin could prove an important factor in the treatment of war casualties. It was essential to press on the work with all possible speed and accordingly, in 1941 Professor Florey and Dr. Heatley visited the United States and introduced penicillin to industrial and research chemists in that country. Now some twenty large American firms are engaged in the production of penicillin. The decision to seek American collaboration was taken at a time when that country was still at peace while here the possibility of commercial development was severely handicapped by the shortage of plant and the likelihood of continued heavy raids. Nevertheless in this country also the urgent need for greater supplies of penicillin for clinical and research purposes was met by its production by a number of commercial firms, while many other workers, too numerous to name, attacked the many research problems still remaining.

The very great importance of penicillin as a war weapon necessarily forbids publication of many of the most recent developments, but it is possible to describe in general terms a great deal of the earlier and most fascinating part of the story. As with so many of the biologically active substances investigated in recent years, such as vitamins and hormones, one of the first tasks was to devise methods of detecting the active substance. It was clear from the start that a large number of different processes would have to be used before a pure product could be isolated from the crude culture fluid, and it was essential to know what happened to the penicillin at the various stages. At that time nothing was known of the chemical or physical nature of penicillin so whatever test was used had to make use of its biological properties. The method eventually chosen was one devised by Dr. Heatley. Bacterial cultures are commonly grown on jellies made from agar, a seaweed product similar to gelatin. If a suspension of bacteria is poured on to an agar plate, allowed to dry and the plate incubated for some hours at blood heat, the bacteria will grow as a dull film over the surface of the agar jelly. To test the penicillin content of solutions short glass or porcelain cylinders are placed on such a plate, sown with the test organism (generally *Staphylococcus aureus*). The cylinders are filled with the solution to be tested and the plate is incubated in the usual way. If penicillin is present in the solutions it diffuses out into the agar surrounding the cylinders and produces circular zones on which the bacteria cannot grow and on which the agar remains clear. Fig. 3 shows a typical test plate. The diameter of the circular zone is a measure of the amount of penicillin in the solution being tested. An alternative method, illustrated in Fig. 4, is to add known quantities of penicillin solution to liquid cultures of the test organism and observe the minimum concentration which will just inhibit growth. For comparative purposes it was necessary to fix arbitrarily a penicillin standard. This was defined

FIG. 1.—A colony of the mould *Penicillium notatum* (centre) growing on agar jelly. After a few days the agar plate was heavily seeded with staphylococci (infective bacteria). A clear ring is seen round the colony. Into this penicillin has diffused and prevented growth of the bacteria.

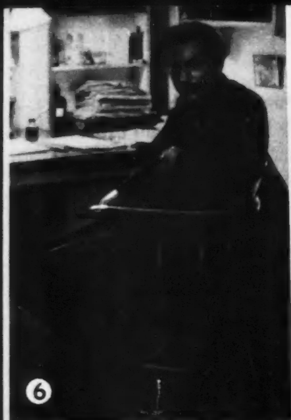
FIG. 2.—The same experiment carried out with a different mould—*Penicillium cyclopium*. Here the visible effect is the same but the substance produced by this mould is penicillic acid which is a highly toxic substance quite unsuitable for therapeutic use.

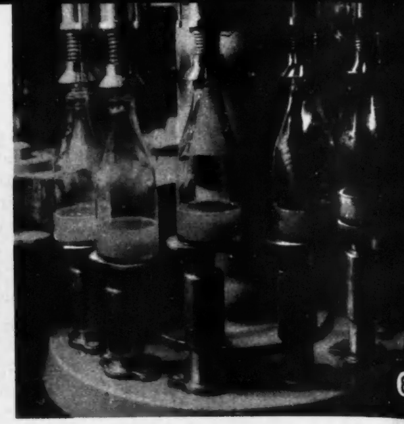
FIG. 3.—The plate and cylinder method of assay developed by Dr. Heatley. Penicillin has diffused out into the agar jelly round the cylinders and prevented growth of the bacteria (see text).

FIG. 4.—Another method of assay using cultures of bacteria in broth. Growth has been suppressed by penicillin in the tubes on the left (see text).

FIG. 5.—Not all bacteria are sensitive to penicillin. In this experiment penicillin has been allowed to diffuse outwards into agar from a central "gutter". Various species of bacteria have been planted on the agar in streaks. Those which are not sensitive to penicillin have grown right up to the gutter. Sensitive ones have not grown in the region on each side of the gutter where the penicillin has diffused out.

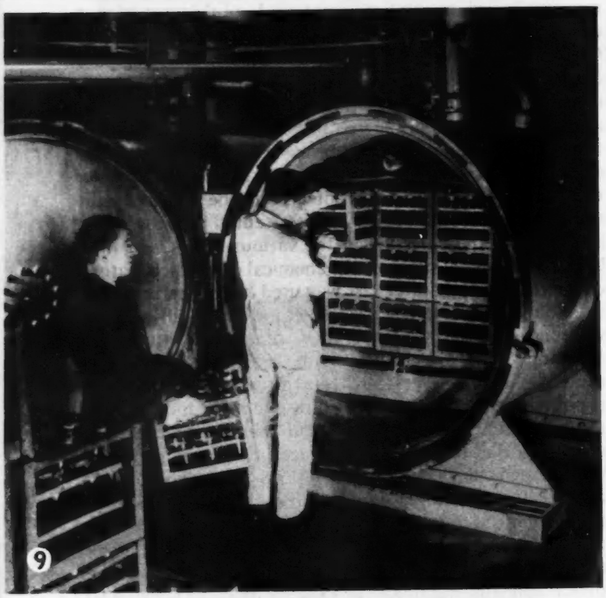
as the an
meter of
almost u
standards
is now k
quantity
1,500 uni
As little
meter w
organism





Difficul

While
others we
of growi
known to
mineral s
reaches a
rapidly.
siderable
in the la
difficultie
wife know
very quic
swarm in
cations so
millions
food for
warm su
grown ma
organism
mould or
in a large
wool or g
particles
adopted e
run into
content o
sterilised
with pur
tributing
does not
must be
known a
complicat
substance



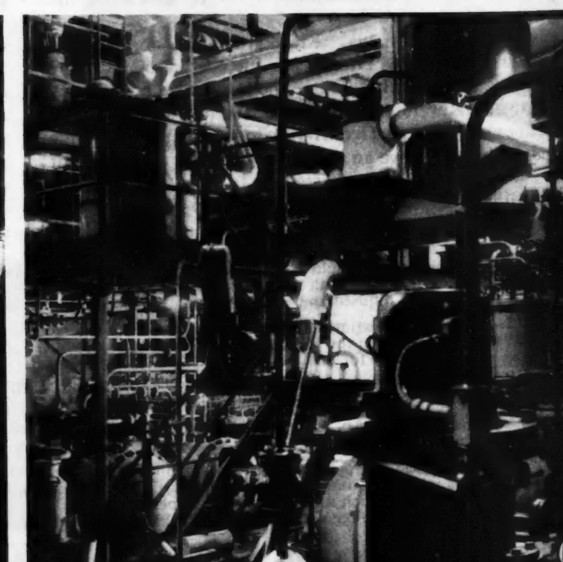


FIG. 6.—
penicillin. (

FIG. 7.—
solution co

FIG. 8.—
to minimise
of nutrient

FIG. 9.—
seeded with
Imperial Cl

FIG. 10.—
bottles. (B

FIG. 11.—
bottles are
rejected an
Industries.)

FIG. 12.—
tured by a

as the amount of penicillin contained in one cubic centimeter of a certain stock solution and this has since been almost universally accepted as the "Oxford" unit. Substandards are prepared from time to time as required. It is now known that one unit corresponds to a very tiny quantity of pure penicillin. The latter contains about 1,500 units per milligramme or some 50,000,000 per ounce. As little as 0·01 unit of pure material in one cubic centimeter will inhibit the growth of the most sensitive organisms.

Difficulties of Production

While experiments were proceeding along the above lines others were carried out to find the most satisfactory method of growing the mould on a large scale. It was already known to grow well on a simple sugar solution containing mineral salts. Grown at 25°C. the antibacterial activity reaches a maximum in 6 to 8 days and then diminishes rapidly. It must be harvested at this peak period. Considerable difficulties were encountered, and indeed still are, in the large scale production. One of the most serious difficulties is that of keeping cultures sterile. Every housewife knows that if food is left in a warm place it goes bad very quickly. This is because bacteria and fungi, which swarm in the air, drop on it and by their rapid multiplications soon give rise to colonies of literally thousands of millions of organisms. These rapidly break down the food for their own purposes and make it useless. The warm sugar solutions on which *Penicillium notatum* is grown make almost ideal breeding grounds for air-borne organisms. Yet air cannot be excluded from the growing mould or it will die. One solution has been to grow the mould in a large number of separate vessels plugged with cotton wool or gauze to permit access of air but to filter off solid particles such as bacterial spores. This method has been adopted even in industry where the weekly production may run into thousands of gallons. The vessels and their content of sugar solution (generally about one quart) are sterilised by heating and then sown under aseptic conditions with pure *Penicillium* cultures. By this method of distributing the eggs among many baskets one contamination does not spoil the whole brew. Air-borne contaminants must be excluded as they rapidly produce substances, known as enzymes, which destroy penicillin. Another complicating factor is that the mould itself may produce substances which destroy penicillin. Again different strains of the mould vary greatly in their capacity to produce penicillin. Much research has been devoted to the isolation of particularly good strains. Even these, however, may for no apparent reason become "tired" and produce less penicillin or even none at all. The type of sugar used can also materially affect the yield while even so minor a change as replacing distilled water by tap water in making up the medium may have an astonishingly large effect. Even under conditions standardised as far as is possible for human ingenuity variations in the yield of penicillin appear in almost every batch. These are only some of the difficulties which occur both in the laboratory and in industry but these alone should provide sufficient explanation of why supplies of this most valuable drug still fall short of the demand. Criticism comes too easily from those who are ignorant of the difficulties.

Penicillin is an unstable substance and unless its treatment is very gentle it is destroyed. Early attempts to extract pure penicillin from the crude culture medium showed that of all the many chemical manipulations which might have been used only three appeared promising. The first method used was distribution between two solvents. If the culture medium is made slightly acid and immediately shaken with ether it was found that the penicillin was extracted into the latter. As ether does not mix with water it can be separated and the watery residue discarded. Unfortunately the mould produces a great number of different substances and penicillin is not by any means the only one extracted by the ether. Nevertheless the method effects a definite purification. Extensive use has also been made of the recently developed technique of chromatography. Briefly this method consists in pouring a solution of a complex mixture, such as that produced by mould fermentation, through a column of absorbent material, generally aluminium oxide, enclosed in a vertical glass tube. While some of the constituents of the mixture pass through the column unchanged others are retained by the absorbent. Those with the strongest affinity for the absorbent are found near the top of the column, those with a weaker affinity nearer the bottom. As a result the different substances become arranged in bands across the column. The column of absorbent can then be pushed out of the tube and the parts carrying the different substances separated mechanically. The penicillin is located by its antibacterial activity. Again this process effects only a partial separation. Finally use has

FIG. 6.—Dr. E. Chain of the School of Pathology, Oxford, who initiated the chemical investigation of penicillin. (M.O.I. photo)

FIG. 7.—Here the mould *Penicillium notatum* is seen growing as a thick felt on the surface of a nutrient solution contained in a glass culture vessel. (M.O.I. photo)

FIG. 8.—Even for industrial production the mould is commonly grown in a large number of small vessels to minimise the effects of accidental contamination. Here bottles are being filled with measured quantities of nutrient solution. (By courtesy of Imperial Chemical Industries.)

FIG. 9.—Crated bottles are seen being packed into huge sterilisers. After cooling the nutrient solution is seeded with the mould and the latter is allowed to grow for 6 to 8 days before harvesting. (By courtesy of Imperial Chemical Industries.)

FIG. 10.—This illustration shows a 6 to 8 day growth of the mould completely covering the liquid in the bottles. (By courtesy of Imperial Chemical Industries.)

FIG. 11.—When the penicillin content of the liquid has reached a maximum the mould is harvested. The bottles are emptied over a filter and the mould squeezed to expel as much liquid as possible. The mould is rejected and the amber-coloured liquid passes on to the extraction plant. (By courtesy of Imperial Chemical Industries.)

FIG. 12.—Part of a large industrial plant for the extraction of penicillin. Penicillin is now being manufactured by a number of British and American firms. (By courtesy of Imperial Chemical Industries.)

FIG. 13 (*left*).—For comparison is shown the experimental extraction plant at the School of Pathology, Oxford. (M.O.I. photo)

FIG. 14.—The earliest therapeutic trials were made with mice experimentally infected with lethal doses of different types of pathogenic bacteria. Here Professor H. W. Florey (centre) is seen injecting penicillin into an infected animal. From many types of bacteria penicillin provides nearly 100% protection. (M.O.I. photo)

been made of the fact that while aluminium amalgam will not attack penicillin it will attack certain of the impurities. By a complicated combination of these three processes it has been possible to isolate pure penicillin. From the material so prepared it has been possible to elucidate the chemical nature of penicillin and this will lead to the ultimate goal: to produce it by synthetic means instead of having to employ the tedious and costly method involving the mould.

Biological Properties

While relatively pure penicillin is needed for chemical investigation its biological properties were determined by the use of material containing only a small proportion of the pure substance. Indeed the earliest preparations, whose high activity led to the belief that they were nearly pure, are now known to have contained only 1% of penicillin. The first problems were to determine (*a*) the range of bacteria sensitive to penicillin and (*b*) its toxicity to animal tissues. With regard to the first of these points Fleming had found that bacteria fell into two classes. Either they were relatively highly sensitive to penicillin or they were hardly affected by it. The Oxford workers confirmed these findings using purified material. Curiously enough this division corresponds closely to an arbitrary one made many years ago by the Danish bacteriologist Gram, and based on the power of some bacteria to absorb certain dyes. According to whether they absorb the dyes or not bacteria are termed Gram positive or Gram negative. Bacteria which are sensitive to penicillin are nearly always Gram positive but the agreement is not perfect and its significance is not yet apparent.

Many pathogenic bacteria are sensitive to penicillin. Among the most sensitive are streptococci and staphylococci, the common cause of septic wounds, and the organisms causing gas gangrene. Hence the great importance of penicillin in the treatment of war wounds.

Other organisms particularly sensitive to penicillin are those causing anthrax, pneumonia, gonorrhoea, syphilli, diphtheria and meningitis. Urgent military needs have so far prevented full exploration of this "non-combatant" field but there is no doubt that when penicillin is available in quantity it will make a very big contribution to the treatment of these diseases.

Many popular accounts have attributed to penicillin the properties of a universal panacea. It must be emphasised that many bacteria which cause disease are almost insensitive to its action. Among the most important organisms

which do not react to penicillin treatment are those which cause tuberculosis, typhoid fever, certain types of food poisoning, Malta fever and plague. It is also valueless, except in so far as it will prevent secondary infection, in the treatment of diseases, such as the common cold and influenza, which are caused not by bacteria but by viruses.

It is possible to prepare non-toxic penicillin preparations suitable for medical use without going through the whole of the elaborate process necessary to produce the absolutely pure material. In animal experiments it was shown that amounts far in excess of those required for therapeutic purposes can be injected without ill effect. In particular it was established that the leucocytes, the body's natural "shock troops" which engulf and destroy invading bacteria, were not affected even by high concentrations of penicillin. Penicillin acts by virtue of its power to prevent the infecting bacteria multiplying and thereby gives the leucocytes the opportunity of destroying those already present. It was shown that, unlike many other drugs which have shown promise, the activity of penicillin was not diminished in the presence of blood, pus or proteins. Nor is its activity reduced by the presence of large numbers of bacteria. In both these respects penicillin differs favourably from the sulphonamides. It does not affect the heart or respiration and can even be injected into the brain or cerebro-spinal fluid. More research was necessary to determine the best method of administration. The drug is excreted rapidly in the urine and to maintain an effective concentration in the blood it must either be administered continuously or at frequent intervals.

Clinical Use

The results of all these preliminary experiments showed that penicillin possessed qualities which made it suitable for trial as a chemotherapeutic agent. It still remained to be demonstrated that its antibacterial powers were as great against bacteria infecting living animals as against those grown in laboratory cultures. The earliest experiments were made with mice. Three sets of experimental animals were infected with many times the lethal dose of three different types of pathogenic bacteria, *Strep. pyogenes*, *Staph.aureus* and *Cl.septique* (the latter one of the organisms causing gas gangrene). After a lapse of one or two hours half the animals of each group were treated with penicillin: the other half was left untreated to serve as a control. In the first experiments it was found that while all the control animals died at least 50% of those treated with penicillin survived. In later experiments it was possible, by modifying the size and frequencies of the doses, to increase the survival rate to almost 100%.

At last the time arrived when it was possible to put penicillin to the test with human patients. Supplies were very small and at first it was possible to select no more than six cases. Six cases of acute sepsis were treated with penicillin by continuous slow injection into a vein. While these first results did not show 100% success they were so promising that it was obvious that penicillin had great possibilities for the treatment of acute infections of the human body. Shortly afterwards, with the co-operation of Imperial Chemical Industries, it was possible to obtain sufficient material to treat a further eighteen cases. Again the results were astonishingly good. These were patients, some on the verge of death, who had failed to respond to any other form of treatment, including sulphonamides. Since that time penicillin has proved its worth at selected centres in this country, in America, and in the treatment of battle casualties. At the moment the greatest obstacle to progress is supply. Every effort is being made to prepare larger quantities by way of the mould, while both in this country and in America research chemists are engaged in the attempt to synthesize penicillin. At the moment it is impossible to predict how soon this problem will be solved and it should be realised that there must in any case be a considerable interval between laboratory success and commercial production.

The way in which penicillin is administered depends on whether the infection is local or one affecting the whole body. In localised infections, such as boils and septic wounds, to which full access can be obtained, penicillin solution is instilled, at frequent intervals, into the affected part, which is usually completely closed except for the small tubes through which the penicillin is introduced or the spent solution withdrawn. The success of this form of treatment depends very much on skilled surgical preparation to ensure that the penicillin has free access to every part of the wound in which bacteria are present. Penicillin may also be applied in the form of a powder or cream. Many infections, however, such as pneumonia, diseases of the bones and septicaemia, can only be reached by introducing penicillin into the body so that the blood stream can carry it to all parts. Although some is absorbed into the blood from the intestinal tract administration of penicillin by mouth is impracticable as the bulk of it is quickly destroyed by the gastric juices. In many cases it has been introduced by direct injection into a vein but at present the most satisfactory method appears to be to allow it to drip slowly into muscle tissue, from which it is readily absorbed.

In penicillin we have a therapeutic agent which is unique in that the size of the dose is not determined by the fear of giving a harmful or even fatal over-dose but primarily by the present difficulties of obtaining adequate supplies. Like the sulphonamides it acts by assisting the natural defences of the body. The sulphonamides however are more toxic, their use being indeed not without risk to the patient, and many times less active against bacteria. This must not be interpreted as a criticism of the sulphonamides as such. It was these drugs that first demonstrated the wide possibilities of chemotherapy and in the past few years and during the present war have saved countless lives. There is no doubt however that penicillin will not only perform many of their functions with greater certainty and less danger, but will also attack many types of infection against which the sulphonamides are ineffective.

Owing to the difficulty of obtaining supplies of material penicillin has had to establish its present reputation very largely in the treatment of desperate cases after all other forms of treatment had failed. Its success in such circumstances augurs well for the time when it will be available, not only as a last resort, but as a means of preventing infection altogether or of checking it in its earliest stages.

[I am indebted to the editor of *Endeavour* for permission to reproduce Figs. 1 to 5.]

The Way of the Sparrow

By ERIC HARDY, F.Z.S.

DURING the nesting season of 1943, my friend Mr. G. C. Miller had five pairs of house-sparrows occupying nest-boxes in his garden at Hoghton in Lancashire. These birds laid 66 eggs of which nine proved infertile. They produced two clutches of six, seven clutches of five, four clutches of four and one clutch of three. Three pairs of the sparrows commenced their nesting operations in April and produced three clutches each, and the remaining two pairs, commencing in May only produced two clutches. The first egg in this sparrow community was laid on April 3rd and the last youngster had flown by July 30th, thus making a nesting season of almost exactly four months during which these five pairs of sparrows raised to maturity 43 offspring.

The normal nesting period—from egg-laying to the flight of young—is remarkably consistent in the sparrow, at least in Lancashire, being about 31 days although one of the above-mentioned pairs reared six young in a fortnight from laying the first egg. In most cases the young hatched out within eight days of the last egg being laid, although one family required 11 days. The height of their nesting season was about May 19th when all five nest-boxes contained eggs. In almost every clutch the last egg laid was paler than the rest, although quite fertile. Mr. Miller kept the most accurate account of his daily observations at each nest-box. In one nest-box when the six young which hatched on June 5th were destroyed by magpies two days later, the first egg of the pair's third clutch, comprising 5 eggs, was laid on June 12th and the clutch completed on the 17th and the young hatched on the 28th and flew on July 14th.

The interesting part played by the cock house-sparrow in courtship extends much further than his familiar waltzing before his unresponsive lady-love in the gutter or upon the house-top. It seems that like the wren and the ringed plover he inherits an aptitude towards some preliminary nest-building efforts as a prelude to courtship. At his house in St. Helens a friend drew my attention to a cock sparrow which alone had constructed a nest of sorts in the roof gutter and proceeded to court passing hen sparrows for some time before successfully mating. In most cases with the birds in the garden at Hoghton the cock was the first to commence nest building and in two instances noted in the middle of March cock birds had the foundations of nests laid before the hen birds started to build. In some cases the cock sparrows continued to carry feathers to the nest for days after the hen commenced sitting. A vacated nest is generally stripped of its feather lining by neighbouring birds.

In feeding the young the cock is generally much more consistent than the rather erratic hen bird, although she will usually spend more time at the nest attending to the needs of the young and the cock gives precedence to her when both birds alight with food at the nest together. The cock also took upon himself the task of driving away the fledged youngsters in the Hoghton garden when they tried to re-enter the nest while the hen was incubating another clutch.

In winter sparrow nests of the domed sort in trees and wall ivy are often used as roosts by wrens, but in the hard winters early in the war Mr. Miller told me that three nests built in large trees in his garden—probably by cock birds—were used solely as roosts and never nested in, one of the nests being dismantled in the spring and the material used for a new nest elsewhere. The cold wet spring of 1941 at Hoghton so latened the nesting season that sparrows were not seen building until March 20th and a full clutch was not found until May 4th, whereas in normal seasons I've found the earliest young out of the nest at the end of February, and I've seen nest building continue so late in the season as the end of October.

The distribution of the sparrow depends much upon the habitations of man, and the coming of a circus or any army camp to those open spaces not normally inhabited by the chirping sparrow mysteriously attracts a resident population of these inhabitants. As I mentioned in "The Birds of the Liverpool Area", a reasonably well conducted bird census showed that the house-sparrow formed 55% of the bird population of a cemetery in the heart of Liverpool, adjacent to the slums, 45% of that of a large suburban public park, but only 2% of the large and completely rural Knowsley Park just beyond the edge of the city. Yet such is the population of sparrows in the towns and built-up areas that over the whole of Lancashire and Cheshire which have at least two-thirds of their area rural, the sparrow is more numerous than any other bird, with an average for the total area of at least 13%. In London some years ago I estimated from many bird counts that there were about one and a half million sparrows compared with only a quarter of a million pigeons. Hyde Park had an average of about two pairs of sparrows to the acre, whereas the Middlesex housing estate at Ruislip had an average of one pair to the acre. I found some eighteen pairs of sparrows living around St. Paul's Cathedral and half a dozen pairs nesting on Blackfriars Bridge while the grounds of the Zoo supported over a thousand house-sparrows who gleaned much of their food from inside the cages, even venturing at times into the lion's cage.

More by accident than anything, the frequent crossing of the Atlantic by sparrows aboard the large ships has always interested me. In over 300 Atlantic crossings my father frequently identified house-sparrows aboard the big Liverpool liners like the old "Baltic." It appears that the birds came aboard ship when in dock, often remaining under the shelter of the upper decks and lifeboats when she sailed, but hard weather quickly tamed them and they soon hopped down the companionways to take food from the hand or be caught and caged by the crew whose "gloryhole" cherished the birds under all manner of special names from chaffinch upwards. Sometimes the birds were seen to survive the crossing and leave the vessel as it neared land at Ireland or Halifax or New York. Sparrows frequently crossed the Atlantic from New York to Galway or Queenstown in like manner, and the same thing was noticed on the "Homeric" between New York and Southampton or Le Havre.

Can Locusts be Controlled?

By SIR GUY A. K. MARSHALL, F.R.S.

To anyone who has seen a countryside devastated by a really large swarm of locusts it might well seem an almost hopeless task to attempt to control so many millions of insects; and unfortunately our Colonial Administrations in Tropical Africa were, until recently, only too ready to adopt this fatalistic attitude. It is true that when locust swarms actually appeared considerable sums of money were spent in organising various methods to destroy those marching bands of young wingless hoppers that were likely to damage crops, or to drive away the flying adults, against which no really effective means of destruction has yet been perfected. But when the swarms began to thin out and disappear, as the cycle came to its end, the organisations against locusts were hastily disbanded, apparently with the idea that nothing more could be done. Yet this was the very time when investigation was most needed, in order to find out why the swarms were disappearing, where they were going to, what were the factors that induced swarming to start, and what were the areas in which these factors were most likely to become operative.

In 1928 there began to develop one of the periodic outbreaks of the Desert Locust (*Schistocerca*), this being the species that is now giving serious trouble throughout the Middle East and East Africa and from Senegal to India. As a result of criticism in Parliament Lord Balfour's Committee of Civil Research (later known as the Economic Advisory Council) appointed a Committee to investigate the locust problem, and funds were at last made available for research.

An Anti-Locust Research Centre was gradually built up in London, where under the supervision of Dr. B. P. Uvarov all available past records of *Schistocerca* were collated; arrangements were made to secure monthly reports of the occurrence and movements of this locust from all countries in Tropical Africa and the Middle East, and these data were entered on series of large-scale maps, so that after a period of years the usual lines of migration began to become apparent, rendering it possible to make approximate forecasts of probable movements of locusts; and finally several investigators were sent out to the Sudan and East Africa to study the habits and behaviour of the insects on the spot.

Blacks and Greens

The search for the origin of swarms seemed at first a somewhat hopeless task, but some years earlier an interesting discovery had been made simultaneously by Dr. Uvarov, while he was still in Russia, and Prof. J. C. Faure in South Africa, that locusts in the gregarious swarming phase showed differences in both structure and colour from individuals of the same species when in the solitary and more sedentary phase; indeed, so marked is the distinction in some cases that the two phases had been treated by taxonomists as distinct species. Although its significance was not at first appreciated, this phenomenon did eventually supply a valuable clue. One of the most striking differences between the two phases is that when the locusts of the swarming phase hatch from the egg the small hoppers are entirely black, and in their subsequent stages they have a conspicuous colouring made up largely of black and orange; on the other hand, the solitaries when they hatch are entirely green, and partly green in the later stages. It was generally assumed that the black coloration was in some way associated with greater activity. But in 1929 I was able to see in Pretoria an experiment carried out by Prof. Faure, who having obtained young green hoppers of the Desert Locust crowded them into a small cage which was automatically subjected to a series of jerks, so as to compel the insects to hop frequently. The result was that, as the insects changed their skins in the process of growth, they developed a very marked approach towards the colours of the swarming phase. Here then was actual proof that the latter phase could be produced by crowding and the resulting stimulation to increased activity. The question then was, how and where does this take place in nature?

In 1926, H. B. Johnston had observed incipient swarms of the Desert Locust developing along the Red Sea coast of the Sudan, but the solution of the problem was mainly due to one of our investigators in the Sudan, R. C. Maxwell Darling, who having for weary months traversed little-known desert regions in Kordofan and Darfur was able to find nothing suggestive of an outbreak centre. He then concluded that throughout the vast area of the Sudan that is subject to summer rains no outbreaks were likely to occur, because the wet season was too short to allow of more than one generation of locusts, so that no large population could be suddenly built up. However, in a belt of country along the Red Sea coast about 200 miles long and from 10 to 20 miles wide the climate is quite different, the rains falling in the winter, and even in the hot dry summer the atmosphere is somewhat humid owing to the proximity of the sea. Into this coastal strip large numbers of the solitary locusts drift in the winter, and Maxwell Darling followed them there. Here conditions were obviously very different. At intervals of roughly 10 or 11 years the rains in this belt are heavy and last much longer than the summer rains inland, so that two generations of locusts, and sometimes a partial third one, can be produced, and food for them is everywhere plentiful. With the onset of the hot dry summer the vegetation dies down except in the vicinity of the mouths of the wadis, or river-beds, and in the patches of cultivation, so that the factors making for over-crowding are thus produced—an increased population and a reduced patchy food-supply; and subsequent observation has proved that swarms do actually originate in this area.

Outbreak Centres

It is clear that this discovery has placed in our hands a new line of defence against locusts. The danger area is comparatively limited, and we know the climatic conditions which will make it suitable for producing swarms, so that if this outbreak centre is adequately patrolled and all

A swarm of locust appears like a dark cloud (*above*) and leave only the naked stalks after their voracious meal (*below*).

the incipi
out into a
swarms f
particula
that swar
breed an
the outbr
are know
menon is
from wh
imbued
laid in cl
hoppers
dense cr
perpetuat
But the
inevitabl
kinds of
prey up
vastly mo
caused b
thinned
scatter, a
solitary p

Unfort
of the Su
centre, s
expeditio
Arabia.
Red Sea
places w
of Omar
Ramacha
the locus
Mekran
operated
also occ
and eve
be prod
happene
will not
though
case, at
in Brus
internati
though
disturbe

There
Tropica
which ra
and fur
which r
Congo,
differen
have be
present
detail h
that the
Dr. Uva
in Fren
swung s
The act
locust e

the incipient swarms in it are killed before they can break out into adjoining territories, we should be able to prevent swarms from starting their invasions, at least so far as that particular centre is concerned. But it might be objected that swarms of the Desert Locust are known to be able to breed and multiply over vast stretches of country outside the outbreak centres. That is quite true, and such places are known as invasion areas. The reason for this phenomenon is that when the initial swarms leave the centre from which they have originated, they are still strongly imbued with the gregarious instinct, and their eggs are laid in close proximity wherever they may go; the young hoppers on emergence continue to collect together in dense crowds, so that the swarm-forming factors are perpetuated, and this may continue for four or five years. But the rapid increase in the locust populations leads inevitably to an increase in their enemies; many different kinds of birds and even mammals (from man downwards) prey upon them incessantly, their parasites become vastly more numerous, and they are decimated by diseases caused by fungi or bacteria. Thus the swarms are gradually thinned out, the individuals tend more and more to scatter, and their progeny then reverts to the harmless solitary phase.

Unfortunately, it was clear that the Red Sea Province of the Sudan was not likely to contain the only outbreak centre, so Maxwell Darling was asked to make two expeditions in 1936 and 1937 to examine the coasts of Arabia. He found that considerable stretches along the Red Sea were certainly outbreak areas, and some suspicious places were found elsewhere, including the Trucial Coast of Oman. Meanwhile that excellent observer Rao Sahib Ramachandra Rao, who has done outstanding work on the locust problem in India, had shown that parts of the Mekran coast of Baluchistan, on the Persian Gulf, also operated as an outbreak centre. Again, a danger spot also occurs on the Atlantic coast of North-west Africa; and even in the middle of the Sahara locusts swarms can be produced when exceptional heavy rains fall there, as happened in 1943. The control of some of these areas will not be easy, but the difficulties are not insuperable, though they may take some time to overcome. In any case, at the last International Locust Conference, held in Brussels in August 1938, the general principle of international control of outbreak centres was accepted, though the details were not worked out owing to the disturbed state of Europe.

There are two other important species of locusts in Tropical Africa—the Tropical Migratory Locust (*Locusta*), which ranges more to the south than does *Schistocerca*; and further south still, the Red Locust (*Nomadacris*), which ranges over the Rhodesias, the southern Belgian Congo, and adjoining territories. These have markedly different habits from *Schistocerca*, and outbreak centres have been found of both species, but they are not at present giving trouble, and they cannot be dealt with in detail here. However, it may be of interest to mention that the careful mapping of swarm movements enabled Dr. Uvarov to show that in its last cycle *Locusta* originated in French West Africa, spread into the Sudan, and then swung south to invade Uganda, Kenya, and Tanganyika. The actual outbreak area was discovered by the French locust expert M. Zolotarevsky, assisted by O. B. Lean, then entomologist to the Nigerian Government. This centre is a strip of about 200 miles along the great bend of the River Niger, which forms a favourable breeding-ground and is liable periodically to heavy flooding, leading to the crowding of the locusts on the temporary islands that rise above the water; and this constitutes the swarm-forming factor. No other outbreak centre has yet been discovered, so that the chances that we may ultimately be able to prevent invasions by this locust seem very promising.

So far we have dealt only with large-scale measures of possible prevention, but when once the locust swarms have broken out of their areas of origin, the outbreak centres cease to be of any special significance, and the insects must then be destroyed wherever they are found.

Anti-invasion Defences

In the past, various measures have been used to exterminate the devastating bands of marching hoppers: beating them or driving them into prepared trenches, or, where the ground was too hard or rocky, driving them against barriers of galvanised iron or American cloth; spraying with poisons or crude oil; burning with flame-throwers; collecting the egg-clusters, or ploughing up the laying grounds so that the eggs would be destroyed by enemies. These methods have mainly been designed simply to protect cultivation, and thus used they are merely palliatives, because they leave untouched the swarms developing in places remote from crops, and which will become a menace later. The system that used to be most usually adopted was driving the bands into trenches or against barriers, but this is feasible only where there is a plentiful supply of cheap labour, which however is usually required when it is also needed for the cultivation of crops.

Experience during the past 20 years has demonstrated that the most efficient and economical method of destroying the hoppers is by means of poisoned bait, the best material being wheat bran mixed with $1\frac{1}{2}\%$ to 3% of sodium arsenite; in arid areas the addition of molasses is usually advocated, and the bait is most attractive when it is damp. The bait is thinly scattered (7 to 10 lb. to the acre) by hand over and around the hoppers or in front of advancing bands, which will often leave vegetation to eat it. This very efficacious method is much simpler as well as cheaper than any other; there is no elaborate machinery often needing repairs in out-of-the-way places, and the amount of labour required is far less than in systems that rely on driving and trenching. Spraying is perhaps equally effective, but is estimated to be at least three times as expensive, and the risk of poisoning stock is much greater.

From time to time protests have been raised against the use of poisoned baits on the ground that they have caused the deaths of domestic animals and especially of wild birds that prey on locusts. But, as stated above, the bait should be thinly scattered, and if the men who apply it are properly trained and adequately supervised, the risk is really negligible; thousands of tons of it have been used over large areas in different countries without any disastrous results. Recently in Arabia our entomologists encountered some opposition from local Arabs who feared that their sheep would be poisoned by the bait and they wisely met the difficulty by buying a flock of sheep and grazing them on baited land. It is true that,

ultimately all the sheep died, but not from poisoning; they were eaten by our locust gangs. The Arabs then appreciated that the destruction of the locusts was actually preserving their precious pastures, and their opposition was then converted into co-operation.

Turning to the birds, some years ago a gentlemen in Rhodesia circularised a number of prominent people in this country protesting that the poisoning of locusts had killed all the storks, which feed voraciously on these insects. These birds on their southward migration to Natal pass in large numbers over Mashonaland, and apparently they had entirely disappeared. But on being questioned, he had to admit that he had not seen a single dead stork, nor could he produce any evidence from other sources. Shortly afterwards we learnt from the Game Warden in Uganda that for the first time he had seen the hills round Kampala white with storks. There can be little doubt that this unusual appearance of these birds in Uganda was directly connected with their absence from Rhodesia, the birds having been drawn away from their normal line of migration by the presence of large swarms of locusts further inland. At about the same time in Holland and Germany people were perturbed by the absence or paucity of storks, and this was also probably due to an unusually plentiful supply of food in North Africa.

But there is also another aspect to this question. In South Africa an experiment was carried out with two lots of 50 fowls, which were all closely similar in size, condition, etc., one lot being fed entirely on poisoned hoppers and the other only on non-poisoned ones. At the end of some months it was found that the lot fed on poisoned locusts were in better condition and had laid more eggs than the other lot. The arsenic had only served as a tonic. On the other hand, it must be admitted that a certain number of small seed-eating birds may possibly be killed by eating the poisoned bran, but there is no evidence that this occurs on any appreciable scale; and such small losses can hardly be allowed to weigh against a method that enables us to safeguard the welfare of millions of people who might otherwise suffer from serious famines.

International Control Essential

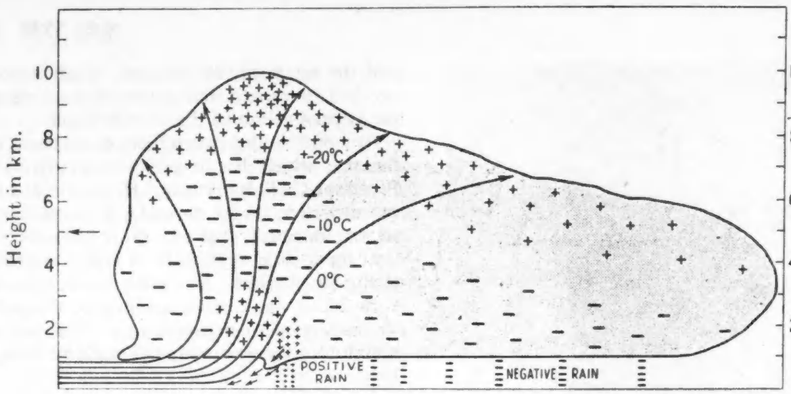
As has often been said, locusts are no respecters of political boundaries, and if any country undertakes a large-scale attack on the pest, no real control can be obtained if adjoining, or even distant, territories fail to carry out adequate measures; the problem must be tackled simultaneously throughout the whole range of the particular species. In Tropical Africa, the Anglo-Egyptian Sudan have been the pioneers in the system of the comprehensive poisoning of hoppers, thanks to the enterprise of H. H. King, then Chief Entomologist there, and his successor H. W. Bedford, and the assistance given by their experts in initiating the present wide-spread campaign has been invaluable. One of the greatest difficulties has been presented by Arabia, which may be regarded at the "key" country for the Desert Locust. Swarms developing in the Sudan and East Africa fly across the Red Sea into Arabia and others come in from India; there they increase and multiply without being molested, and later return migrations take place, while other swarms may enter Palestine and Syria or go north into Persia. Not only so, but it was impossible to get any information as to what was happening there, except from a few isolated spots, such as Aden, and thus the probable movements of these important swarms could not be forecast. Now, however, thanks to the wisdom of King Ibn Saud, Maxwell Darling, of the Sudan Service, has recently been able to organise the first large locust campaign ever undertaken there, and an information system is being built up. The vastness of the country and the great difficulties of transport make it improbable that all the swarms can be killed, but even a material reduction in their numbers will have a very beneficial effect for adjoining countries.

Abyssinia has been another *terra incognita*, but recently it has been possible to send a Locust Mission there, under D. Buxton, who is starting an information service and endeavouring to train the local people in methods of locust control, though for various reasons the conditions are very difficult.

Last season was one of the peak years of infestation, and countries like the Sudan and India carried out attacks on locusts on a larger scale than ever before. Other countries were given external assistance, and in Kenya, for instance, the hopper campaign covered an area of 7,000 square miles, and in spite of the large number of swarms the loss of important crops was kept down to quite small proportions. Energetic attacks like this in all the countries affected might well serve to reduce the length of the swarming cycle.

There remains still another possible line of attack on this plague which has not yet been developed. So far, no really effective means of killing off the adult flying locusts has yet been devised. In certain areas during the cold dry season swarms of adults are found, generally on the margins of deserts, in a less active state than usual, awaiting the arrival of the rains that will enable them to lay their eggs. If in this stage they could be destroyed by some effective poison, this would clearly be a much more economical measure than to wait until they have laid their eggs in many different areas and then proceed to kill the resulting hoppers. A promising poison has already been discovered, but there are various technical difficulties in its use that have yet to be overcome, and tests on a large scale must first be carried out. Arrangements for such tests are now in preparation.

It will thus be seen that there are three possible successive lines of attack, and when these have been perfected and comprehensively applied, there seems no reason why we should not ultimately be able to reduce the destruction caused by locusts to relatively small proportions.



Courtesy of the Royal Society

FIG. 1.—Diagram showing the air currents and the electrical charge distribution observed in a typical heat thunderstorm. (Proc. Roy. Soc. A **161**, 309, 1937)

Lightning and Spark Discharges

J. M. MEEK, D.Eng., F.Inst.P.

RESEARCH on the lightning discharge has greatly increased during recent years, mainly because of improved techniques in the recording of high-speed phenomena, and rapid progress has consequently been made in our knowledge of the electrical characteristics and manner of development of the discharge, although our understanding of the physical processes involved is still by no means complete. In addition to the general interest of the physicist in lightning as a scientific phenomenon, there has been a further incentive to the search for information concerning lightning in that it is a matter of increasing importance to the electrical engineer. Not only is lightning one of the main sources of radio atmospherics, but it is a major cause of damage to overhead electric-power distribution systems, which form particularly susceptible targets for lightning. To protect such electrical systems the distribution engineer is concerned to know the magnitude of the currents involved in lightning discharges, and their variation with time, so that suitable protective apparatus can be designed.

The frequency of occurrence of lightning over the earth's surface is higher than most people realise, and the annual amount of damage caused amounts to many millions of pounds. It is probable that about 100 discharges occur during each second, and as the voltage involved in each discharge is probably some 50 million volts, and the average charge lowered to ground is about 20 coulombs, the resultant energy amounts to 100 million kilowatts, which is approximately some ten times greater than the total generating capacity of the main electrical supply undertakings in this country.

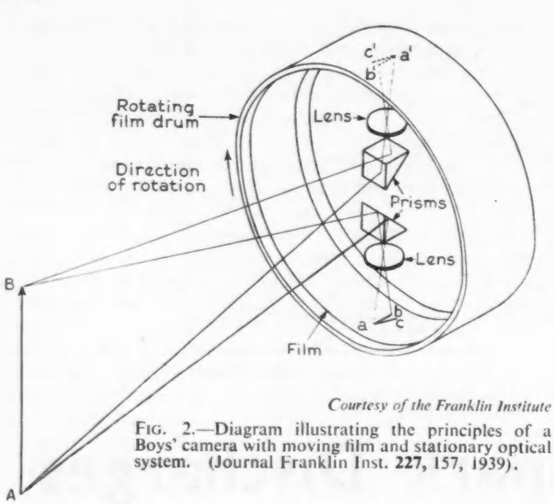
As lightning is but a particular instance, on a large scale, of the electric spark, it is natural that many of the methods adopted in the study of lightning are closely similar to those used in the study of the spark. Differences in the two studies do arise, however, in that lightning is a random uncontrolled phenomenon, whereas the spark can be produced readily in the laboratory under controlled conditions; the spark, therefore, forms the more convenient subject for research. Many of the characteristics of the lightning discharge can be reproduced in the laboratory spark, and the investigations in the field and in the laboratory are in many ways complementary. But research on the spark is by no means confined to its bearing on the elucidation of the lightning discharge. The spark is itself a problem of great interest to the physicist, and extensive studies have been made to determine the fundamental processes which govern the initiation and development of spark discharges. Further, as the spark is one of the main factors contributing to the breakdown of electrical insulation, the engineer is also concerned to obtain a better understanding of the spark mechanism.

The principal methods used in the investigation of the lightning discharge, and the thunderstorm, are as follows:

1. Measurement of the voltage gradients at the ground, between ground and cloud, and within the thundercloud.
2. Oscillographic studies of the electromagnetic fields radiated by lightning discharges.
3. Photographic studies of lightning discharges.
4. Measurements of discharge currents.
5. Laboratory experiments designed to simulate the characteristics and effects of lightning, together with investigations of the mechanism of development of the electric spark.

It is clearly not possible to give an adequate treatment in this article of all such methods of investigation, and it is proposed to present first a brief picture of the electrical nature of the thundercloud, followed by an account of some of its electrical characteristics, and the effects which it produces.

Finally, a description will be given of certain laboratory investigations on the spark which have a particular bearing on lightning studies.



Courtesy of the Franklin Institute

FIG. 2.—Diagram illustrating the principles of a Boys' camera with moving film and stationary optical system. (Journal Franklin Inst. **227**, 157, 1939).

The Thundercloud

Direct measurements of the distribution of electric charge in thunderclouds have been made by Sir George Simpson and his colleagues, who used free balloons to carry their recording apparatus. They found that the cloud structure is generally of the form indicated in Fig. 1, which illustrates both the electrical and the meteorological conditions. The main portion of the cloud base is negatively charged, and the upper portion is positively charged, but a concentration of positive charge frequently occurs in the cloud base, in that region where the air-currents are most vigorous. Precipitation of water in the cloud-base takes place in the form of raindrops, but in the upper regions of the cloud the temperature falls to a value well below freezing-point and precipitation is in the form of ice-crystals. The measurements also indicate that the maximum electric field existing within the cloud, and between cloud and ground, is not more than about 100 volts per cm. During fine weather the electric field in the atmosphere is about 1 volt per cm.

The mechanism whereby electric charge is generated in the thundercloud is still the subject of controversy, and the variety of meteorological conditions in the cloud make it probable that several mechanisms may be involved. Simpson has explained his measurements in terms of two physical processes, which depend on the presence of either raindrops or ice-crystals, and relate, therefore, to the lower and upper portions of the cloud respectively. The first process is based on experimental evidence concerning the breaking of water-drops in a current of air, when the broken drops are observed to become positively charged and the air negatively charged. This accounts for the charge distribution in the region of strong air currents in the cloud base, where positively charged water-drops accumulate while the air with its negative charge is swept up to higher regions of the cloud. The other process, which depends on the interaction of ice-crystals with the air, was originally put forward by Simpson to explain the atmospheric electrification produced during blizzards in the polar regions, and suggests that the impact of ice-crystals causes the crystals to become negatively charged, and the air positively charged. Such a process may be invoked to explain the distribution of electric charge in the upper portion of the thundercloud.

Among the alternative theories of cloud electrification, the one which has received most attention is that of Professor C. T. R. Wilson. He considered the movement of water-drops in the normal fine weather field, which is in such a direction that the drop becomes polarized with the upper side negatively charged and the lower side positively charged. It can be shown experimentally that such falling water-drops accumulate a negative charge, by the attraction of negative ions. This mechanism would account for the predominating negative charge in the cloud base.

The Lightning Discharge

The general impression given to a normal observer by a lightning discharge is that of an instantaneous flash, but sometimes a flickering sensation is caused, and statements have occasionally been made that lightning was seen to travel down from cloud to ground, or in the reverse direction. Towards the end of the last century some progress was made in the understanding of the problem as the result of an experiment by Hoffert, who photographed a lightning discharge with an ordinary camera which he oscillated in a sideways direction when making the exposure. The resultant photograph showed eight separate flashes of closely identical form, and he, therefore, established that the lightning discharge is not necessarily a single flash but may consist of a series of discharges which succeed each other at various intervals of time, and each of which follows the same path between cloud and ground. Other such photographs were later made by B. Walter and others, which confirmed the multiple nature of the discharge process.

Meanwhile a new type of camera was devised by Sir Charles Boys in 1900 for the particular purpose of the photography of lightning. This camera consisted of two lenses rotating about a common axis, and arranged to focus the image of the discharge on a fixed photographic plate. There is then a distortion of the photographed image as a result of the relative movement between lens and film, and distinction can be made between any portion of the discharge which becomes luminous before another portion. Knowledge of the relative speed of lens and film enables a deduction to be made of the speed of development of the lightning discharge. The schematic diagram of Fig. 2 shows a recent design of such a camera, in which relative movement of lens and film is effected by a rotating film with stationary lenses.

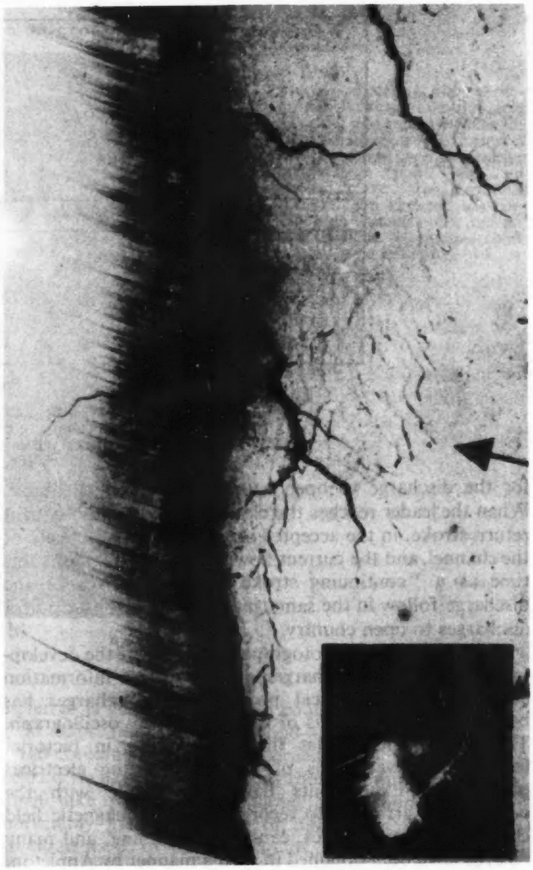
Unfortunately Sir Charles Boys had no opportunity to secure a photograph of lightning with his camera, and it was not until 1933 that the camera was successfully used, in South Africa, where Professor B. F. J. Schonland and his associates obtained their first lightning photographs. The results of these and subsequent photographs with the rotating camera have greatly contributed to the advancement of our knowledge concerning the lightning discharge mechanism. Schonland found that the discharge not only contains a series of multiple strokes, but that each stroke consists of a sequence of discharge processes, which he named the leader and the return stroke. The first stroke of the discharge is initiated by a

leader stroke, which, in the case of discharge to open country, develops from cloud towards ground at an average speed of about 20 million cms. per second, the equivalent of almost half-a-million miles per hour. The luminosity of the channel produced by the leader stroke is not continuous, but exhibits sudden increases at intervals of about 50 millionths of a second, which give a stepped appearance to the leader stroke, as illustrated in the photographs of such leader strokes given in Fig. 3. A diagrammatic representation of the leader-main stroke sequence is shown in Fig. 4 (a).

When the stepped leader stroke reaches ground, an ionised channel (a path along which the air molecules electrically charged and along which a discharge will travel more readily than through ordinary air) has been formed connecting the cloud with the ground, and a return stroke develops upwards from the ground to the cloud along this channel at a speed of about 2,000 million cms. per second, nearly one-tenth the speed of light. The current involved in the passage of the return stroke is many times higher than that in the leader stroke, and the light emitted is correspondingly greater.

After an interval of some 0·03 seconds, a second stroke, may occur. This is preceded by a so-called "dart leader" which develops from cloud to ground along the same channel produced by the first stroke. The speed of the dart leader is some ten times in excess of that of the initial stepped leader, and again the leader is followed by a return stroke. Other such strokes may follow at similar intervals. Branching of the discharge is only observed in the first stroke of the series, when the branches are initially produced by the stepped leader and are later retraced by the return stroke.

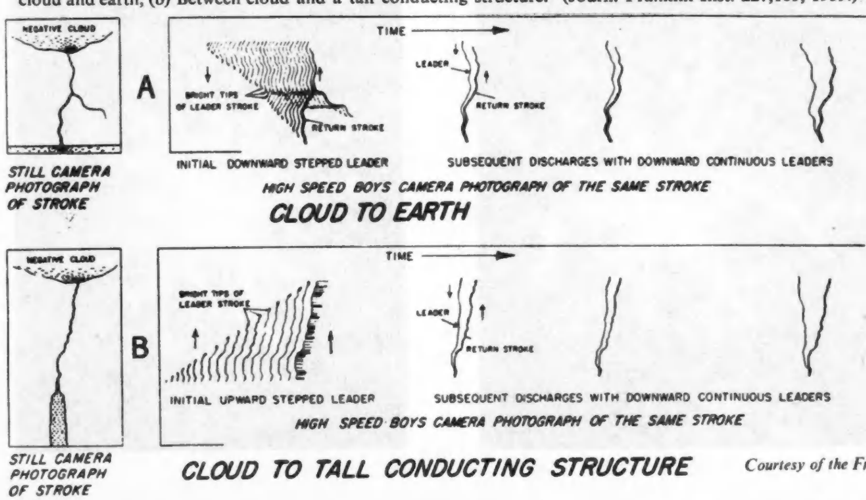
Lightning discharges to high buildings differ in some characteristics from those to open country. K. B. McEachron has shown in his investigations of lightning striking the Empire State building in New York that the discharge is usually initiated at the earthed tower in the form of a stepped leader stroke, which develops upwards to the cloud, as shown diagrammatically in Fig. 4 (b). The speed and manner of growth of this stepped leader stroke corresponds to that of the stepped leader stroke



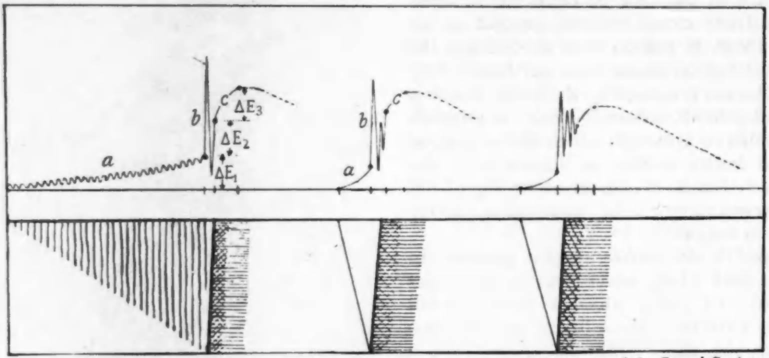
Courtesy of the Royal Society

FIG. 3.—Photographs of two stepped leader strokes, associated with different discharges. The lens-film movement is such that time increases from right to left. (Proc. Roy. Soc. A **152**, 595, 1935.)

FIG. 4.—Diagrams illustrating the general mechanism of development of lightning discharges: (a) Between cloud and earth, (b) Between cloud and a tall conducting structure. (Journ. Franklin Inst. **227**,185, 1939.)



Courtesy of the Franklin Institute



Courtesy of the Royal Society

FIG. 5—Electric field change at the ground close to a lightning discharge, compared with the photographically observed mechanism. (Proc. Roy. Soc. A **166**, 66, 1938.)

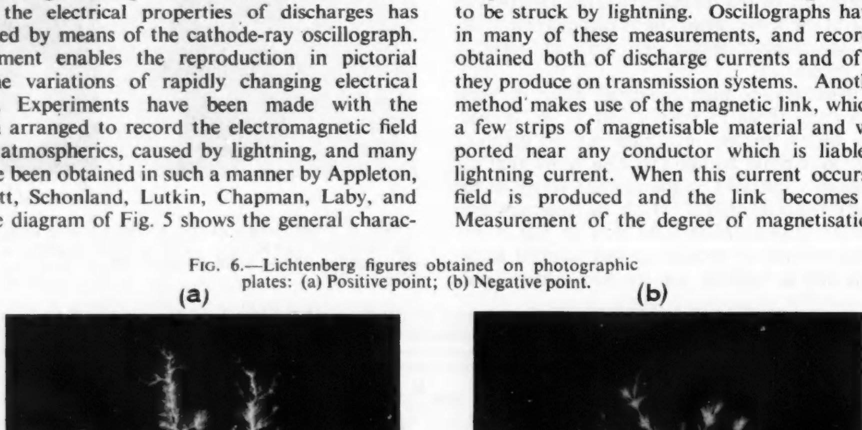
for the discharge to open country, as described above. When the leader reaches the cloud, there is no subsequent return stroke, in the accepted sense, but the luminosity of the channel, and the current flowing in it, persist for some time as a "continuing stroke". Later strokes of the discharge follow in the same manner as that observed for discharges to open country.

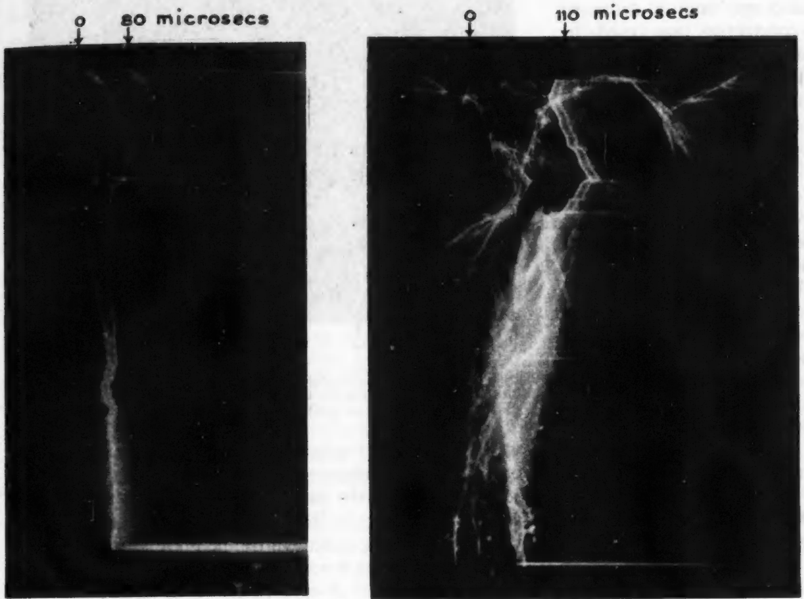
In addition to the photographic evidence of the development of lightning discharges much valuable information concerning the electrical properties of discharges has been obtained by means of the cathode-ray oscillograph. This instrument enables the reproduction in pictorial form of the variations of rapidly changing electrical phenomena. Experiments have been made with the oscillograph arranged to record the electromagnetic field charges, or atmospherics, caused by lightning, and many records have been obtained in such a manner by Appleton, Watson-Watt, Schonland, Lutkin, Chapman, Laby, and others. The diagram of Fig. 5 shows the general characteristics of the usually observed variations in electric field close to a lightning discharge and their relation to the photographically-recorded mechanism. Determinations can be made from these electric field records of the electric currents and quantities of charge transferred in the separate strokes of the discharge.

Direct measurements have also been made of lightning discharge currents by the use of recording apparatus coupled to transmission lines and high buildings likely to be struck by lightning. Oscillographs have been used in many of these measurements, and records have been obtained both of discharge currents and of the voltages they produce on transmission systems. Another recording method makes use of the magnetic link, which consists of a few strips of magnetisable material and which is supported near any conductor which is liable to carry a lightning current. When this current occurs a magnetic field is produced and the link becomes magnetised. Measurement of the degree of magnetisation enables a

FIG. 6.—Lichtenberg figures obtained on photographic plates: (a) Positive point; (b) Negative point.

(a) (b)





(a) (b)

FIG. 7.—Rotating film photographs showing the development of leader and return strokes for spark discharges: (a) Across a 130 cm. gap between a positive high-voltage point and an earthed plane; (b) Across a 100 cm. gap between a negative high-voltage point and an earthed plane. (1 micro-second equals one-millionth of a second).

determination to be made, from calibration curves, of the crest value of the current which has flowed. An instrument known as a fulchronograph makes use of a series of such magnetic links, mounted around the circumference of a rotating wheel, and in this way the variation of current with time can be determined.

The klydonograph is another instrument which is used to record the transient voltages which are produced on transmission lines as a result of lightning. A known proportion of the voltage is applied to a metal rod which rests on the emulsion of a photographic plate, behind which is an earthed metal plane. When the photographic plate is developed a discharge pattern, known as a Lichtenberg figure, is found to have been formed. The size and character of this figure depends on the polarity, the magnitude, and the wave-shape of the applied voltage, and the instrument can be calibrated to act as a voltage measuring device. Two typical figures, obtained with positive and negative applied voltages, are shown in Fig. 6.

As a result of the measurements of the electrical characteristics of the lightning discharge the following conclusions may be drawn. The lightning discharge in most cases carries a negative charge from cloud to ground. The crest magnitude of the current averages about 10,000 amps., but values as high as 160,000 amps. have been measured. The high current values last for very short periods of time, of only a few millionths of a second but much lower currents, of the order of 100 amps., may persist for times as long as several tenths of a second. The usual number of strokes present in a single discharge is two or three, though as many as 30 have been observed. The total charge conveyed to ground by a complete discharge is generally some 20 coulombs—the equivalent of 20 amps. flowing for 1 second—but occasional values of 100 coulombs have been recorded.

So far we have considered only those lightning discharges which take place between cloud and ground. But an appreciably greater number of discharges occur within the cloud itself, or between clouds, while others start on their way towards ground but do not succeed in reaching it. Although it is not possible to make direct measurements on such discharges, information has been obtained by studies of the radio atmospherics which they produce.

Other features associated with lightning which are of general interest are such phenomena as St. Elmo's fire and ball lightning. The former is a glow observed at the tops of towers and mast heads under certain conditions, and is probably a corona discharge produced as a result of the increased atmospheric electric field under a thundercloud. There does not appear to be a satisfactory explanation of ball lightning, but there is reasonable evidence that it does occur and is not an optical illusion as some people have suggested. It is usually in the form of a luminous ball several inches in diameter, which is thought to appear sometimes following a normal lightning discharge and lasting for a few seconds.

Damage caused by Lightning

The damage caused by lightning varies according to the type of object which it strikes. Poor electrical conductors, such as trees, may be shattered by the high pressures suddenly generated by the passage of the large current in the return stroke, and fire may result if the discharge current continues, even at a relatively low value, for sufficient time. Such considerations apply to the

fabric usually employed in buildings, and in order to protect the latter lightning conductors are used to provide a good conducting path to ground. The discharge current then passes through the conductor in preference to the building material, and damage to the latter is thereby prevented. For effective protection it is important that the conductor should follow a straight path to ground. Also the resistance of the conductor, and that of the earth into which it is buried, should be low. The earth's resistivity varies considerably, according to the nature of the soil and the amount of moisture present, and this is a matter of concern in the design of transmission lines. In districts where the soil resistivity is high, the ground resistance may be reduced by attaching counterpoises, consisting of buried lengths of bare cable, to the feet of the transmission towers. In sandy regions, the passage of the discharge current sometimes causes fusion of the sand into tubes, known as fulgurites, which are usually about half-an-inch in diameter and may be several feet long.

The presence of high electrical fields often causes freak effects in aeroplanes flying through thunderclouds. Visible glow and streamer discharges appear on the propeller tips and other extremities of the plane, and cases are reported where such effects were also observed inside the plane. However, the effects of such electrical disturbances may not be so hazardous as those produced by the strong air-currents, whose presence in thunderclouds is confirmed by aircraft pilots. Moored balloons are likely targets for lightning, and it is possible that they may initiate discharges in the manner already described for high buildings.

The currents involved in lightning discharges are so large as to cause fatal injuries to human beings and animals in the path of the discharge, and also, in some cases, to those situated close to the point where the discharge reaches ground. The discharge current spreads out radially from this point, and high voltage gradients may be developed on the surface of the ground, so that the voltage across the length of ground separating the feet may be appreciable. Many instances are reported of deaths caused in this manner to cattle, which are more susceptible to electric shock than are human beings, and whose feet bridge a greater length of ground.

The Spark Discharge

The development of high-voltage generators, capable of generating voltage surges of several million volts for times lasting tens of millionths of a second, has enabled the production in the laboratory of sparks several feet in length. The visual appearance of these sparks is in many ways similar to the lightning discharge, and experiments with the rotating-film camera show that the leader and the return stroke are both present in the spark mechanism. These experiments were initiated by Schonland and Allibone, subsequent to the former's discovery of the leader-main stroke sequence in the lightning discharge. The initial results showed the presence of the leader stroke, but it was only detectable across a small proportion of the gap. Later experiments by Allibone and Meek revealed the importance of the external circuit conditions on the development of the discharge and photographs

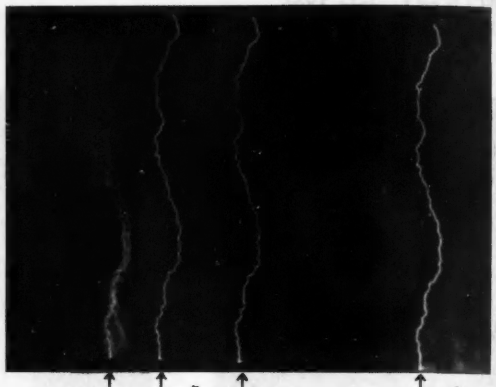


FIG. 8.—Rotating-film photograph of a spark discharge, containing multiple strokes, across a 75 cm. gap between a positive point and an earthed plane.

were obtained of the leader stroke traversing the complete gap between the electrodes.

Differences in the nature of the leader stroke are observed according to the polarity of the electrode from which it develops, as shown by the photographs of Fig. 7. In the case of a spark across the gap between a high-voltage positive point and an earthed plane, as illustrated in Fig. 7 (a), a leader stroke is initiated at the positive point and develops across the complete gap to the earthed plane. The return stroke then takes place along the path previously ionised by the leader stroke. The speed of the leader stroke depends to some extent on the external circuit conditions, but is of the order of that recorded for the initial leader stroke in the lightning discharge. Stepped development of the leader stroke is also observed. Branches of the discharge are formed by the leader stroke and are later retraced by the return stroke.

The manner of development of the discharge between a negative high-voltage point and an earthed plane, illustrated by the rotating-film photograph of Fig. 7 (b) is different in several respects from the positive discharge described above. The discharge is initiated at the high-voltage electrode by a negative leader stroke, which exhibits a pronounced stepped development. After the negative leader has grown a distance about one-third of the gap length a positive leader stroke develops upwards from the earthed plane to meet the descending negative leader in the mid-gap region, and the return stroke then takes place along the pre-ionised channel.

By suitable adjustment of the external circuit a multiple series of strokes, similar to that observed for lightning, may be obtained in the laboratory spark, as shown in Fig. 8. The first stroke of the series is seen to be preceded by a leader stroke, but the resolution of the camera is insufficient to show the presence of dart leaders preceding the subsequent strokes. All the strokes follow the same path as that traced out by the first stroke.

The studies of the spark with the rotating-film camera have been supplemented by measurements with the cathode-ray oscillograph and synchronised oscillograms have been obtained relating the variations of voltage and current in the discharge-gap with the photographically observed development of the discharge. Many independent oscillographic studies have also been made by a

number of investigators to observe the formative time required for a spark to develop, and also the statistical timelag between the application of the voltage and the initiation of the discharge. Other research workers have made successful use of the cloud-chamber and the electro-optical shutter in their investigations, while much has been learnt concerning the spark mechanism by the study of surface discharge patterns, similar to those shown in Fig. 6. This extensive research programme on the electric spark has been carried out not only for discharges in air, at various pressures, and between a variety of shapes of electrodes, but also for discharges in many other gases.

Laboratory research relating to lightning discharges is by no means confined to studies of the spark mechanism. Many experiments have been made to reproduce the effects caused by lightning, such as the fusion of wires and lightning conductors, the crushing of metal tubes, the puncture of metal sheets, and the damage of various electrical apparatus. For this purpose high-current generators have been developed, in addition to the high-voltage generators already mentioned, and both equipments are widely used in the testing of electrical apparatus which is liable to be subjected to damage caused by lightning.

Tests are also carried out with high-voltage and high-current surges in the development of apparatus used in the protection of buildings and electrical systems such as lightning conductors, overhead earth-wires, lightning arresters, and surge absorbers. Further, deductions may be made of the magnitude and duration of the currents involved in lightning discharges by comparison of the effects caused to electrical apparatus by voltage and current surges, artificially produced in the laboratory, with the damage caused to similar apparatus by lightning.

Conclusion

The description given here covers only a small proportion of the extensive research work which has been carried out in many parts of the world on lightning, and but briefly surveys some of the related work on spark discharges. There are still many aspects of the problem which remain the subject of controversy, and more experimental research is required before an adequate explanation can be given of all the fundamental processes which are involved. The need for a better understanding of these basic mechanisms lies not only in the general interest which these arouse in the mind of the physicist and the engineer, but also in the importance of the information in the design of electrical insulation and protective equipment. Such progress in design has already been effected as a result of our increased knowledge of the lightning and spark mechanisms, and the continuance of research on these subjects will no doubt cause a still further improvement in the design and reliability of various forms of electrical apparatus in the future.

The writer wishes to express his thanks to Dr. A. P. M. Fleming, Director and Manager of the Research and Education Departments, Metropolitan-Vickers Electrical Co. Ltd., for permission to publish this article.

DAME HELEN GWYNNE-VAUGHAN—*cont. from p.* 200.

also developed some original ideas about heterothallism, a phenomenon of self-sterility that occurs in some fungi; she holds that this is not homologous with dioecism—the separation of the sexes in different individuals—but should be considered as a special adaptation, replacing, and in many respects fulfilling, the function of a dioecious condition which has been lost, not impossibly in connection with the transition of water-fungi into land plants.

One of the most interesting aspects of Dame Helen's scientific work is the considerable research school which she founded. Many Birkbeck students have, after graduation, remained in the botanical department to carry out research, and by a careful piecing together of time contrived to make excellent use of their limited leisure. Many research students joined her department from the Dominions and from foreign countries; a Chinese professor, a Belgian priest, an Egyptian lecturer were among those who spent a year in her laboratories; visitors from the Dominions and the United States were frequent, some of them staying for several months or returning at intervals for discussion and advice.

Finally her association with the Auxiliary Territorial Service during this war must be mentioned. In the inter-war years Dame Helen had kept in touch with the friends she had made on war service, and the maintenance of those contacts proved valuable when towards the end of the 1930's it seemed that auxiliary services of women might again be required. Three years before Munich she was responsible for initiating what was called "Emergency Service", an organisation which provided the nucleus of officers for the A.T.S. and the W.A.A.F. The A.T.S. was formed in 1938, with Dame Helen as commandant of its School of Instruction in London. July 1939 took her to the War Office as director of the A.T.S., a post which she held until she was retired on age in 1941. She again ranked as chief controller, but with an equivalence this time to a major-general. In September 1939 she had under her command nearly a thousand officers and 16,000 auxiliaries. After mobilisation the A.T.S., as an indispensable force within the British Army, expanded rapidly and smoothly, so that to-day, with A.T.S. officers holding staff appointments and auxiliaries undertaking responsible and often highly technical jobs, Dame Helen can look around her and take pride in the contribution that the service she helped to plan is making to the nation's war effort.

The Night Sky in August

M. DAVIDSON, D.Sc., F.R.A.S.

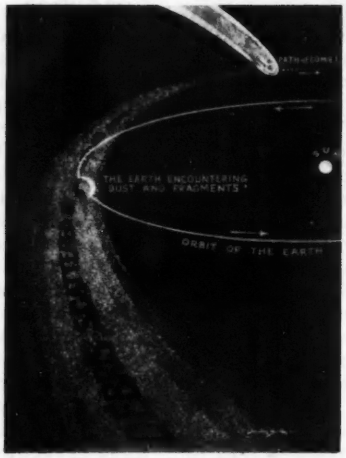
The Moon.—Full moon occurs on August 4d. 12h. 39m. U.T., and new moon on August 18d. 20h. 25m. The following conjunctions take place:

August			
14d. 20h.	Saturn in conjunction with the moon,	Saturn	1°N.
20d. 03h.	Venus ,,	Venus	2 S.
20d. 19h.	Mercury ,,	Mercury	8 S.
21d. 04h.	Mars ,,	Mars	4 S.

In addition to these conjunctions the following conjunctions between the planets will take place:

August		
13d. 13h.	Venus in conjunction with Jupiter	Venus 0.6°N.
26d. 15h.	Mercury in conjunction with Venus	Mercury 6.1°S.

The Planets.—Mercury sets at 20h. 16m. at the beginning of the month, less than half an hour after sunset and a little over half an hour after sunset at the end of the month. The planet reaches greatest eastern elongation on August 10. It is not well placed for observation during the month. Venus sets at 20h. 16m., 19h. 54m. and 19h. 24m. at the beginning, middle and end of the month respectively, and is too close to the sun for favourable observation. Mars sets at 20h. 35m. at the middle of the month and is too close to the sun to be well seen. Jupiter and Saturn are no longer visible.



Tuttle's Comet has left meteoric debris round its orbit, and this debris is spread out considerably. The earth cuts through the debris each August and a shower of meteors, known as the Perseids, takes place, the maximum intensity of the shower being on August 10–12.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

August	Sunrise	Sunset
1	4h. 23m.	19h. 49m.
15	4h. 44m.	19h. 24m.
31	5h. 09m.	18h. 49m.

August	Moonrise	Moonset
1	17h. 23m.	0h. 58m.
15	1h. 00m.	17h. 39m.
31	17h. 51m.	1h. 33m.

The Perseid meteor shower is active during August, reaching a maximum on August 10 to 12, but meteors belonging to this shower can be seen early in the month and even towards the end of the month also. These meteors are due to the debris of Tuttle's Comet encountering the earth's atmosphere.

JUNIOR SCIENCE

About Rain

Usually we do not like the rain. But we would be much worse off without it. If there were no rain there would be no rivers, no lakes and no plants, and life on land could not exist. The earth would be deserted and dead.

Have you ever thought where the rain comes from? The sun warms the surface of the sea and changes some of the water into water vapour. This water vapour is quite invisible. At the same time the water gives some of the heat which it has received from the sun to the air above it. This heated air together with the water vapour rises up into the atmosphere. The reason for this is that when the air is warmed it expands and becomes lighter. When it rises the warm air is replaced by cool air which flows in from those parts of the earth which have not been heated so well by the sun. This flow of air is the wind.

When the warm air rises up into the atmosphere it expands more and more because there is a smaller weight of air pressing on it the higher it rises. When thus expanding without receiving heat the air cools and the water vapour in it turns again into liquid. Tiny droplets of water appear which are so small that they float in the air. These droplets form the clouds which we see in the sky. When the tiny droplets in the clouds get together they form bigger drops which are too heavy to float in the air, and fall to earth as rain.

You can see the same thing happening when a kettle with water boils. The water vapour rising from the spout forms a little cloud when it passes into the cool air. If you hold the lid of a saucepan into this cloud (Fig. 1) big drops of water begin to collect on it and finally drop off as "home made" rain. K.M.

The Bookshelf

This Changing World. Edited by J. R. M. Brumwell. (Geo. Routledge & Sons, Ltd.; pp. vi + 286; 12 plates and many illusts.; 12*s.* 6*d.*).

THE reprinting of magazine articles is a two-edged proceeding. Some things written in a hurry are worth preserving, others better buried in the obscurity of the library. Mr. Brumwell's collection of the articles which appeared in *World Review* under this general title seems to have got all the roses and none of the thorns. One is perhaps conscious of a lack of unity. One notices, too, that each writer starts afresh and carves out an introduction for himself instead of plunging into a new aspect of some single subject as is the case in an ordinary book. The unity is in each article, and though on reprinting they seem a little short for the magnitude of the subjects which they each cover, the best impression may be obtained by recognising that the book is a collection of units and reading the articles separately in consequence.

It is a distinguished enough galaxy of authors. Among the names familiar to scientists are those of Bernal, Crowther, Darlington, Needham and Waddington, each of whom sketches in some aspects of what they think is of importance in a field in which they are specially interested. The strength of this book is its topicality. It is an answer, and a very good one, to the question "What is going on?" If the reader feels that any particular answer is incomplete (and how could it be otherwise at no more than 4000 words per subject) Mr. Brumwell has anticipated his needs and has provided an excellent bibliography at the back. Anyone can, with sufficient patience, get distinguished men to write articles on subjects which interest them, and no one will have any doubt, even before opening this book, that the authors will do their stuff in the various superlative ways which have made them distinguished, but it is the quality of the editing and the discreet personal suggestions made before pen is put to paper which transforms what might have been a mere aggregation into a happy party. In considering such a book, the modest editor who gets his team into shape deserves no little share of the credit. D.S.E.

Progress and Archæology. By V. Gordon Childe, D.Litt., D.Sc. (The Thinker's Library No. 102: London, Watts & Co., Ltd., 1944, pp. 119, 2*s.* 6*d.*)

INTO this small volume Prof. Childe has compressed a stupendous mass of archæological fact. He has outlined the discoveries and researches of the last 150 years, the period during which the study of man's past has acquired the methods and assumed the proportions of a science. His book is not, however, a mere recital of facts—this as Prof. Childe points out, would be merely tedious, but it is an analysis of the results of archæological discovery which demonstrates the trend of human history as made manifest by the material facts. These facts are here set out five chapters which deal respectively with the food quest, tools, machines and materials, warmth and shelter, intercourse and the diffusion of culture, funerals, and sacrifice and temples. A final chapter deals with the results of progress. It will not surprise those who are acquainted with the author's previously expressed views to find that he is still on the side of the optimists. There can be no question, he would maintain, that the facts of archæology demonstrate in human history a progression from a state in which man is completely at the mercy of his environment to one in which he has become not merely emancipated in greater or less degree, but in turn is himself assuming control of his circumstances and thereby of his destiny. In other words he is drawing nearer to the attainment of complete freedom of thought and action in conditions of security than has ever before been possible. Not, indeed, that Prof. Childe would deny that there have been set-backs and may be again; but he says: "In archæological history evil appears as merely negative, it is not cumulative"; Whereas progress, that is to say the cumulative process to be discerned as a concomitant to the development patent in the material facts of the archæological record, "has made human life richer and more diversified". E.N.F.

Diccionario de Quimica, publicado en inglés, baja la dirección de Stephen Miall, LL.D., B.Sc. Traducción espanola y notas por el Dr. José Giral, ex-Rector y Catedrático de Química de la Universidad de Madrid. (Editorial Atlante, S.A., Altamirano 127, Mexico, D.F., 1943; pp. xviii + 1004; $75.00).

WE welcome this Spanish edition of Dr. Stephen Miall's *Chemical Dictionary*, for it will greatly assist scientists in their reading of the growing number of important South American scientific books and papers.

Dr. José Giral, who is responsible for the translation and additional matter, is of course well-known in both European and South American scientific circles. At present he holds a professional appointment at the Polytechnical Institute of Mexico. He is also on the editorial panel of the Mexican scientific journal *Ciencia*, which approximates to our own *Nature*.

Dr. Giral has taken the opportunity of bringing the original English edition of the Dictionary up to date. Indeed, about one-third of this Spanish edition is of new material, either in the form of scientific articles containing the latest information on many matters in which the English edition is now out of date or did not cover, or in biographical notices. With the incorporation of these additions, the *Diccionario de Quimica* must now take its appropriate place alongside the selected dictionaries on the international scientist's bookshelf. Both the translator and the publishers are to be congratulated upon a sound piece of work. P.V.D.

Doctor Darwin. By Hesketh Pearson. (Penguin Books, 1943; pp. 143; 9*d.*).

ERASMUS DARWIN is certainly most often remembered as a grandfather of Charles Darwin; occasionally he is mentioned as a writer of verse highly appreciated by Cowper and Walpole and the author of a poem on botany of an evolutionary trend, of which the second part, though the first to be issued, was styled *The Loves of the Plants.* Only to students of eighteenth-century literature and social history in such works for example, as the memoir of him by Anna Seward, does he appear in anything like his full stature—a commanding figure, physically bulky and somewhat ungainly, mentally quick-witted and no less sharp of tongue. His abilities, his achievement and his qualities as a scientific and philosophical thinker made him an outstanding personality in his immediate circle, even though it included such men as Priestley, Josiah Wedgwood, James Watt, and Samuel Galton, all members of the famous Lunar Society which Darwin founded.

Born in 1831 Erasmus Darwin graduated at Cambridge, where he also acquired a medical degree, and qualified as a medical man after a course of study at Edinburgh. He settled as a general practitioner at Lichfield, having made a very brief stay in Nottingham. Later in life he migrated to Derby, but by that time his reputation was firmly established. By many he was considered the most eminent physician of his day; but some mistrusted his proneness to experiment—a characteristic which comes out in his other activities, especially in his fondness for mechanical inventions, which on one occasion at least brought his to grief. In his profession, however, it is evident from contemporary accounts that he was far in advance of his age. His experimental methods were based not upon a mere disregard for medical precept, but upon a close and intimate study of individual idiosyncracy. It was the same habit of mind and capacity for close observation and inference that led Darwin to formulate a theory of evolution which anticipates modern theory in a remarkable manner.

Mr. Pearson, himself, a descendent of Darwin on both sides, affords an entertaining panoramic view of the members of Darwin's circle, of which Thomas Day, the author of *Sandford and Merton* is not the least interesting figure. They all belonged to that section of society which was destined to play so decisive a part in English social reform in the late eighteenth and early nineteenth centuries. E.N.F.

Far and Near

Black Aphis on Sugar Beet

In collaboration with the British Sugar Corporation, the British Sugar Beet Seed Producers' Association and the National Farmers' Union, arrangements have again been made by the Ministry of Agriculture whereby machines will be available this season to deal with Black Aphis infestations. The methods of control are: (1) machine dusting of fields by nicotine, which, carried out on a large scale has resulted in a kill of about 95 per cent., and (2) gassing with vaporised nicotine by special high clearance tractors, which has achieved a mortality approaching 100 per cent. Gassing is preferable where the foliage is much rolled or crinkled, or where a very rapid kill is required. This service is intended primarily to safeguard crops of sugar beet seed and sugar beet from attack by this pest. Subject to this consideration the machines will also be available to deal with infested crops of other seeds, peas, beans, strawberries, and Brussels sprouts, particularly in sugar beet growing areas.

Successful control requires correct scientific advice and accurate timing of treatment. A grower who observes Black Aphis on his beet crop is therefore asked immediately to inform his factory fieldman or where the crop is grown for seed, his contracting seed merchant, so that the necessary arrangements for treatment can be made without delay. Outside the Eastern Counties the provincial advisory entomologist should also be notified.

History in Clay

Sixty-six years ago a 20-year-old assistant geologist doing research work in a district north of Stockholm pondered over an excavation in which the clay formed even layers sharply differentiated from one another. This young geologist was Gerard De Geer, whose investigations have become of very great importance to geological science.

Thanks to the "time scale" worked out by Professor De Geer, based on the mud layers deposited by the inland ice, it has been possible to determine very exactly the spread and retreat of the ice during the glacial periods in various parts of the world. His measurements have, for instance, revealed that it took 4,300 years for the huge ice-sheet from the present south coast of Sweden up to the province of Jämtland, a stretch of about 500 miles, to melt. About 9,700 years ago the southern edge of the several hundred yards thick ice-sheet lay on a level with the Lake Mälar valley in Central Sweden. The measurements which De Geer and his assistants carried out in the Stockholm district have given that area a special position in quaternary-geological science.

When this Swedish scientist died on the 23rd July, 1943, only the first part of his great life's work, *Geochronologiae Sueciae Principes*, which was ready in 1940, had left the printer's. The second part is in course of preparation and is being edited by his widow, Ebba De Geer, who was associated with him on many of his expeditions.

De Geer's labours in this field over more than 60 years has just been linked up with another branch of science. At a meeting of the Anthropologico-Geographical Society in Stockholm some time ago Dr. Börje Kullenberg, of the Oceanographical Institute in Gothenburg, described a scheme for continuing De Geer's investigations far out in the Baltic with the aid of a vacuum plummet constructed by himself and Prof. Hans Pettersson, head of the Institute. This instrument is expected to make it possible to effect borings of up to 80 feet in depth in the bed of the sea and raise the core to the surface.

Some years ago the American geophysicist Piggot designed a cannon plummet in which the tube that takes up the core is fired down into the bed of the sea by means of an explosive charge. By this means it proved possible to bring up plugs 2 or 3 yards in length, but the tube could not be driven any deeper; even then the charge was dangerously high, and accidents were not unknown. It was with these facts in mind that the two Swedish scientists designed the vacuum plummet, which can operate down to a depth of about 20,000 feet. At the upper end of the plummet tube is a thick-walled steel globe, which is pumped empty of air before the plummet is lowered. When the point of the plummet reaches sea-bottom, a valve opens and the water from the tube rushes into the globe, being forced into it by the enormous pressure of the surrounding water. By this means the tube is driven downwards into the sea-bottom—the water-pressure itself being the driving force. Some years ago cores of over 12 yards in length were successfully brought up from the bed of the Gullmars Fjord on the Swedish West Coast.

The Swedish oceanographers have drawn up an extensive investigation programme. It is intended with the aid of the Pettersson-Kullenberg vacuum plummet to probe the conditions under the ocean bed, applying the De Geer method also to the stratified mud deposits beneath the bed of the Baltic. Professor Pettersson declares that the vacuum plummet, the technical development of which has not been completed, appears to be the most effective means yet devised for revealing the secrets of the deep and fathom the past evolutionary history of the oceans.

Factors in Factory Output

The fifth report of the Industrial Health Board under the title *A study of Variations in Output* (H.M.S.O., 1944, 4d.) describes an enquiry made by Dr. S. Wyatt and four assistants into the effect the reduction of working hours introduced generally into factories in the latter part of 1942 had upon output. Prior to that period in the war, very long working weeks—commonly as high as 70 hours—were being performed in many factories. For the purposes of this enquiry the output of groups of 200 fully experienced workers in various sections of different factories was examined for four weeks preceding the reduction and for twelve weeks following it. Where the actual output could not be checked, the use of piece-work earnings was resorted to. An examination of the output of two-shift or three-shift days was also made.

The report clearly shows that alone the reduction of working hours beneath the generally accepted but still too high 60 to 65 hours for men and 55 to 60 hours for women was not a vital factor in maintaining output. Six other factors affecting output were brought to light: changes in design of product; mechanical breakdowns and variability in material; flow of working material; technical improvements in machines operated; changes in general lay-out of work; and personal factors. The type of work performed has also to be taken into consideration. The report also shows that on the whole a greater variability of output is to be expected with a three-shift system than with a two-shift.

This particular examination of the problem of output variations indicates how difficult it is to assess the optimum number of hours per week a man or woman can work and maintain their best output. Most of the industrial processes surveyed were affected by other factors in addition to the hours of work. As the report says, "The results should be regarded as samples of output curves over a period of several weeks, during which time the change of hours was only one, and often not the most important factor". What is needed is a scientifically controlled investigation of this urgent problem.

A.Sc. W's. Post-War Policy

The full text of the resolution passed at the Annual Council of the Association of Scientific Workers at their Whitsun Conference (briefly reported in the April Discovery, p. 191), together with a statement of the Association's Post-War Policy for Science, is now available from the Association headquarters 73, High Holborn, W.C.1. It is anticipated that this latter document will be expanded at a later date in further publication.

Future Co-operation in Science

The Year Book of the Royal Society, 1944, covering the operations of the Society down to September, 1943, includes in the Council's report a summary of the recommendations of the British Commonwealth Science Committee which was set up by the President in 1941, with the object of ensuring the widest measure of scientific co-operation within the British Empire. After holding twelve meetings the Committee now makes three specific recommendations. First, that the governments of the various English-speaking countries might usefully maintain permanent scientific and technical representatives in London and possibly also in other capital cities of the English-speaking world. Secondly that such representatives might be constituted a

British Commonwealth Scientific Collaboration Committee: and thirdly that in the event of scientific and technical representatives of the United States and of other countries, not members of the British Commonwealth of Nations being established in London arrangements should at once be made to seek their co-operation in all problems of common interest. Among the questions with which it is recommended that the British Commonwealth Committee should deal are the organisation of discussions of matters of common interest and the recommendation of proposals for common action, the maintenance of contrast with all agencies and organisations for the collection and dissemination of scientific information, and the projecting of schemes for the widest co-operation in research.

Marine Turbine Research

A RESEARCH and Development Association has been established by British shipbuilding and marine engineering firms to develop the application of steam and gas turbines for marine propulsion. The association will operate independently of the British Shipbuilding Research Association though close liason will be maintained to ensure interchange of information and to avoid duplication of researches.

Penicillin at the Front

WAR correspondents with the Allied forces in Normandy report that penicillin is provided to all medical units right down to the first-aid posts.

Pan-American Research Centre

RESEARCH centres established and kept up with international support are likely to become increasingly important in the future, and a good example of what can be done is provided by the Inter-American Institute of Agricultural Sciences, which has its headquarters in Costa Rica. The convention making this organisation a permancency has already been signed by the U.S.A., Costa Rica, Nicaragua, Panama, Cuba, Ecuador, the Dominican Republic, Honduras, El Salvador and Guatemala, and remains open for signature by other American countries. The work of organising this institute began early last year, and it has made a start with immediate research projects aimed at the improvement of quinine, rubber, fibres, tropical fruits and vegetables. The buildings that will form the nucleus of this research and training centre are being constructed at Turrialba, near San Jose. The institute plans to act as a research centre serving all the American republics, and it is expected that the numerous agricultural stations open in Central and South America in recent years will co-operate closely with it.

The Zoo in War-time

1,600,000 people visited the London Zoo last year, as compared with 1,900,000, the average for the three pre-war years. The number of animal species on view was just under 1600, scarcely more than half the pre-war figure.

Agricultural Education

THE Minister of Agriculture and Fisheries and the President of the Board of Education have jointly appointed a Committee to advise them on all aspects of agricultural education to be provided by local education authorities and particularly on the educational policy and methods of training to be adopted at farm institutes.

The Committee will be a permanent body and will advise the two Ministers on such matters within their terms of reference as they think fit and on any questions on agricultural education up to and including farm institute level that may be referred to them.

The Chairman of the Committee is Dr. Thomas Loveday, M.A., Vice-Chancellor of Bristol University, who was a member of Lord Justice Luxmoore's Committee on Post-war Agricultural Education and is Chairman of the Ministry's war-time committee on Higher Agricultural Education.

The Minister has also appointed a Committee to consider the character and extent of the need for higher agricultural education in England and Wales and to make recommendations as to the facilities which should be provided to meet the need. This Committee will deal with agricultural education provided by agricultural colleges and university departments of agriculture and will take over the functions of the Ministry's war-time Committee on Higher Agricultural Education.

Institute of Physics

THE position of physicists and those desiring to enter the profession during the demobilisation period has received preliminary consideration from the Board of the Institute of Physics. In the annual report it is stated that the institute's officers are in touch with the Ministry of Labour and National Service on this matter, while evidence has been submitted to the Ministry's committees on "Higher Appointments" and on "Further Education and Training of Demobilised Persons" through the medium of the Joint Council of Professional Scientists. The membership of the institute is now over 1900, and at the end of 1943 there were 654 Fellows and 714 Associates. Another point in the report is that the Australian branch has increased its number of fellows and associates by 50%.

Value of Diphtheria Immunisation

IN the House of Commons recently the Minister of Health was asked to make a statement regarding the effectiveness of diphtheria immunisation in view of the fact that without immunisation there were 53,000 cases in 1916 whereas in the third year of this war there were over 50,000 cases though one third of the children had been immunised. Mr. Willink pointed out that there had been a sharp decline in the number of diphtheria notifications between 1941 and 1943; in the former year there were 50,000 cases as against 34,000 in 1943; the number of deaths was almost halved—2641 against 1370. "By the end of last year", added the Minister," about half of the child population was immunised. It is estimated that in two years—1942 to 1943—about five out of six of the children notified as suffering from diphtheria and about 29 out of 30 of those who died from it were not immunised."

Research in Occupied Countries

IN a letter to *The Times*, the President of the Royal Society recently made an appeal for the "Horace Darwin Fund". Sir Henry wrote as follows:

"The Royal Society has received from a generous donor, who wishes to remain anonymous, an offer of the sum of £2,000 to initiate a fund which it is desired to associate with the memory of the late Sir Horace Darwin, F.R.S., whose scientific vision and enterprise have had such important influence on the instrumental equipment of scientific research and its applications. Appropriately to that commemoration, the object named for the proposed fund is the provision of apparatus and materials for restoring the equipment of laboratories and institutions for scientific research in countries now occupied by our enemies. Such restoration must play a vital part in enabling allied countries, now so long the victims of aggression, to create anew their scientific and economic life.

"The Royal Society, being in full sympathy with the objects thus indicated, has agreed to create the "Horace Darwin Fund" for their furtherance, and has accepted the contribution offered for its initiation. It cannot be doubted that the allied countries which the enemy has occupied and despoiled will need such help on a very large scale; and the offer of it from this country would certainly strengthen the bonds of collaboration with our own scientific community, and contribute to the promotion and maintenance of the ultimate European settlement. The fund will be held by the Royal Society, for application to this purpose as soon and as rapidly as the liberation of the occupied countries, and the facilities for obtaining the required equipment, make effective action possible.

"Contributions to the 'Horace Darwin Fund' should be sent to the treasurer of the Royal Society, Burlington House, W.1."

Expansion of Medical Research

THE Lord President of the Council was questioned in the House of Commons last month as to the possibility of expanding the research programme of the Medical Research Council. Mr. Attlee stated that various plans are under consideration and that the Medical Research Council have already been able to initiate certain new schemes with a view to development as soon as circumstances allow. Among other things, he said, they have recently established a Research Unit in Applied Psychology at Cambridge; and Research Units in Industrial Medecine, Human Nutrition and Otology in London. The new buildings for the National Institute for Medical Research, completion of which has been interrupted by the war, will also make it possible to expand the Council's central establishment.

Science in China

The hon. secretary of the British Branch of the Natural Science Society of China, Mr. Yap Pow-Meng, has written a brief but very interesting booklet entitled "The Place of Science in India" which is published by the China Campaign Committee, 34 Victoria Street, London, S.W.1, price 6d.

Feeding Cattle on Lupins

Trials with sweet lupins as a source of cattle fodder and poultry food are being made in England, and preliminary results are recorded in the June number of the *Journal of the Ministry of Agriculture*. The seeds, which have a protein value about twice that of pea meal, have so far proved satisfactory when fed at the rate of some 10 per cent. of the total ration, without signs of poisoning. The sweet lupin differs from the ordinary garden lupin in that the toxic alkaloids are absent, so that it can be eaten by all classes of livestock, whereas only sheep will eat bitter lupins (sometimes with fatal results). The plant can be grown on very light soils, and appears to be able to withstand a soil acidity even greater than rye can tolerate.

Birthday Honours

The Birthday Honours List included the two great names associated with penicillin —Professor Alexander Fleming and Professor Howard Walter Florey—an account of whose work in this connection is given on another page of this issue. They have both received by a knighthood. Another knight is Dr. Percival Hartley, Director of Biological Standards, National Institute for Medical Research, and he also has been engaged on work connected with penicillin, particularly on the standardisation side. The Comptroller of the Patent Office, Mr. M. F. Lindley is similarly honoured, as is Dr. A. D. Crow, C.B.E. who was recently named as the ballistics expert directing development work on the rocket gun (*see* Discovery, April 1944, p. 127). Professor G. I. Taylor, F.R.S., Yarrow Research Professor of the Royal Society, also receives a knighthood.

. . . .

The president of the Royal Society, Sir Henry Hallett Dale, is appointed to the Order of Merit.

. . . .

Sir Walter Moberly, Chairman of the University Grants Committees, becomes a K.C.B.

. . . .

Dr. J. B. Hutchinson, Geneticist with the Colton Research Station, Trinidad, and Cotton Adviser to the Comptroller for Development and Welfare in the W. Indies gains a C.M.G., as does Mr. R. W. R. Miller, A.J.C., Director of Agriculture, Tanganyika Territory.

. . . .

New C.B.E.'s include Professor J. D. Cockcroft, chief superintendent, Air Defence Research and Development Establishment, Ministry of Supply; Major Kenneth Gordon, joint managing director, Imperial Chemical Industries (Fertiliser & Synthetic Products), Ltd.; Mr. Ernest Frederick Relf, F.R.S., superintendent of the National Physical Laboratory; Dr. B. H. C. Matthews, F.R.S., head of the R.A.F. Physiological Laboratory.

. . . .

The O.B.E. has been awarded to the following: Mr. J. M. Dodds, head of research department, Metropolitan-Vickers; Mr. Fred Gray, general manager, I.C.I. (Metals), Ltd.; Dr. Frederick Measham Lea, F.R.I.C., assistant director of building research, D.S.I.R.; Mr. Leslie Linzell, A.R.I.C.; Dr. W. J. Rees, F.C.S., Dr. Jnanendranath Ray, F.I.C.; Dr. A. G. Pugsley, Superintendent, Royal Aircraft Establishment.

. . . .

The following have received the M.B.E.: Mr. Frederick Basil Garner, A.R.C.S., A.I.C.; Mr. Geoffrey Herbert Halton, Steatite and Porcelain Products, Ltd.; Miss Hilda Margaret Hyatt, assistant director, Molasses and Industrial Alcohol Control. M.O.S.: Mr. Ivor Paul Llewellyn, M.I.Chem.E., J.P., director, Peter Spence & Sons, Ltd.

. . . .

Personal Notes

Mr. S. Livingston Smith, superintendent of the engineering department of the National Physical Laboratory, has been appointed director of research of the new British Shipbuilding Research Association.

. . . .

Professor E. L. Hirst has been appointed Sir Samuel Hall Professor of Chemistry and Director of the Chemical Laboratories at Manchester University in succession to Professor A. R. Todd.

. . . .

The death occurred on June 4 of Mr. Emil Hatschek, aged 75. A Hungarian by birth, he spent his youth in Vienna, where he was a student of the Polytechnicum, and came to England in 1888. Two years later he was naturalised. A brilliant and original investigator in the field of colloid chemistry, he initiated regular courses in that subject at the Sir John Cass Institute in 1911. These lectures, affording the first formal instruction on colloid chemistry ever given in this country, he continued until 1935, when he retired on reaching the age limit. His writings include "The Physics and Chemistry of Colloids," which ran to five editions, and "The Viscosity of Liquids." In 1932 he was the guest of honour at the Colloid Symposium held in Ottawa.

. . . .

Summer School in X-Ray Crystallography

A Summer School in X-Ray Crystallography applied to industrial problems is being held in the University of Cambridge in September along the lines of the school organised last year which proved to be very successful. It is being arranged again by the Departments of Physics and of Mineralogy and Petrology in co-operation with the Board of Extra-mural Studies.

In the course, which has been modified as a result of the experience of last year, emphasis will be placed on the interpretation of practical work and on the application of different techniques to various problems. It is particularly designed for scientists and technicians who are using the methods of X-Ray diffraction in industry and who have had no systematic training in the subject.

The Summer School will extend from September 4 to September 16, 1944. In view of the present shortage of staff, apparatus and materials it will be possible to accept only a limited number of people, and application to attend must be made before July 24. Further information can be obtained from the Secretary of the Board of Extra-mural Studies, Stuart House, Mill Lane, Cambridge.

. . . .

Archæological Research in Mexico

Two reports have just been issued by the Smithsonian Institution, Washington, D.C., on excavations in Southern Mexico, carried out under the direction of Matthew W. Stirling from 1938 to 1941. The first of these, *Stone Monuments of Southern Mexico*, by the leader of the expedition himself, deals with highly interesting and important evidence bearing upon the practice of carving and erecting large stone monuments, which was one of the most conspicuous of the achievements of the aborigines of tropical America. These carved stone monuments attained their highest development among the Maya of Yucatan, especially in connection with the use of the calendar, but they have been found in a distribution which is more or less continuous from Peru and Colombia in the South up to and including the Mexican states of Vera Cruz and Oaxacai n the North. Stirling's record now adds new or little-known evidence from four sites in Vera Cruz in the form of carved stelae, monuments, altars, as well as colossal heads, human and animal, all in stone. From this evidence it emerges that a stelae-cult flourished in the western area at a relatively early date.

The second report, *Ceramic Stratigraphy at Cerro de las Mesas*, by Philip Drucker, deals with one of the Vera Cruz sites excavated by the Stirling expedition, that at Cerro de las Mesas. This is a mound and habitation site in a low-lying plain area, flooded in the wet season, bordering on the bay of Alvarado. The mounds, of which some are in groups, were found on excavation to have been erected for ritual purposes only. Several types of "wares" were established, the main criterion being slip and/or paint, and a relative chronology determined. When this is correlated with present knowledge of the pre-Columbian cultural sequence for tropical America, Cerro de las Mesas would appear to cover the culture known to American archæologists as Teotihuacan I, from the site of that name and dated at about A.D. 1, to the second period of the Mexican Aztec culture of, say, about 1200 A.D.

Printed and published in Great Britain by Jarrold & Sons, Ltd., The Empire Press, Norwich.

Aspects of an Industry

ABOVE THE SALT

AT the household table of the middle ages the saltcellar was the symbol of class distinction. It separated the lord, his lady, their guests and privileged men, who sat "above the salt", from the menials and retainers who sat " below " it. The saltcellar has long since lost this symbolic meaning, but it remains a witness to the need of the human body for salt. Only a very small part of the salt consumed in food actually comes from the saltcellar. Much more reaches the table in butter, and bacon, or in other cured or preserved foods. But the total quantity of salt used for domestic purposes is trifling compared with the huge tonnages taken by Industry. Salt is one of the more important chemicals with which Nature has enriched the British Isles. It occurs in different parts of the United Kingdom in extensive beds formed by the drying up, in remote ages, of inland seas. The layer of salt in course of time became buried, and is known as rock salt. But only a little of the salt used today is obtained by mining this rock. By far the greater part is made by evaporating the brine which results when rock salt is dissolved either naturally by surface water which seeps through to the beds, or by water specially introduced through boreholes. In some salt fields the natural brine rises to the surface and here salt has been made since the Roman occupation of Britain. Either as a mineral or as brine salt is the raw material for the manufacture of a wide range of important chemicals which are in their turn the raw material for many industries. Glass and soap-making, for example, use great quantities of alkali, which is made from brine and limestone. The dye-stuffs, textile and paper-making industries could not be carried on without chemicals based on salt. Salt is used in the manufacture of non-ferrous metals and to some extent in agriculture. British salt is shipped overseas to form an extensive export trade. It is the responsibility of the British chemical industry not only to ensure that British salt beds are efficiently developed and used, but by constant research to improve upon ways of using salt to the benefit of Industry and the public.

Imperial Chemical Industries Limited, London, S.W.1

surface
y water
me salt
nd here
upation
salt is
e range
urn the
l soap-
alkali,
he dye-
could
on salt.
metals
h salt
export
hemical
eds are
onstant
using
public.

V 1